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The ILLUMINATING ENGINEER

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Edited by LEON GASTER

10/6 Yearly. THE JOURNAL OF SCIENTIFIC ILLUMINATION. 1/- a Copy.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

This number contains the complete account of the *Discussion* of ***The First Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops,*** opened by Mr. L. GASTER at the last meeting of The Illuminating Engineering Society on November 23rd, 1915.

Other Articles include:—

SEMI-INDIRECT OFFICE LIGHTING—HALF-WATT FITTINGS—REVIEWS OF BOOKS, &c.

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EDITORIAL.

The Health of Munition Workers and Industrial Fatigue.

On pp. 485-506 readers will find the account of the discussion at the last meeting of the Illuminating Engineering Society on the Report of the Departmental (Home Office) Committee on Factory Lighting. As we have dealt with this matter previously at some length, and as the various points raised in the discussion are replied to by the author on pp. 504—506, it is unnecessary to say much more on the subject now. The discussion was very timely, and quite showed the desirability of a general interchange of views at the present stage.

In the future it must be our task to ensure that the matter is kept well to the front and that problems at present unsolved receive attention, and we do not doubt that the Society will be able to do useful work in this respect.

The conditions of health of munition workers are now receiving a great deal of attention, and we have referred to the work of the Committee now studying this subject. We are glad to see that the Committee, while proceeding with the general course of their investigations, have already shown their activity by the prompt publication of two interim reports dealing respectively with "Sunday Labour" and "Industrial Canteens." Seeing that all such correlated factors affecting the health of workers require to be considered in connection with any detailed researches on the effect of light on health, it is worth while to give some account of the conclusions already reached by the Committee.

These two questions—hours of labour and facilities for refreshment—have long been in the minds of social reformers, and have often come before the notice of Government departments. Anyone who has had occasion to visit factories where special attention has been paid to the workers' well-being, will agree that this care has been well repaid by its effect on the work done.

It is gratifying to note that amongst other recommendations the Committee point out that canteens should be properly lighted, heated and ventilated. These three requirements are now coming to be considered conjointly. The additional value of a canteen, when cheerfully and attractively illuminated, is generally acknowledged. In the kitchens, again, adequate illumination is essential in the interests of cleanliness and for the proper preparation of food; the detection of stale or unwholesome food does not depend only on the sense of smell, but frequently upon changes in the colour of the material. Such changes are a sign of deterioration, and require a good light for their detection.

From his own experience the writer is fully convinced of the good work to be done by industrial canteens, particularly in cases where many of the workers live a long way from the work. A rush home to a hastily prepared meal, and in all kinds of weathers, is not the best preparation for further work, and it is surely preferable that the operator should be able to sit down in leisure to enjoy a good meal on the premises.

As regards the question of seven-day labour, it has long been recognised that intervals for recuperation are essential if the worker is to keep his fitness and alertness of mind and body. In the great emergency which arose in connection with munition work special efforts were required, and in many cases the hours have been extremely long. As an *emergency measure* this was perhaps inevitable in some factories, but it requires little reflection to see how seriously such conditions would react on the national health if persisted in for any length of time. It is therefore only prudence to husband our "man-power," and to avoid at all costs the danger of permanently straining and weakening the physique of operators throughout the country.

We have also before us the Interim Report on the Investigation of Industrial Fatigue presented before the Home Office by Professor A. F. Stanley Kent, of Bristol University. Professor Kent has made experiments with a variety of tests for fatigue; for example, the "Ergograph," by means of which the ability to raise a given weight with the forearm is taken as a measure of muscular fatigue; the diminution in acuteness of the senses of vision and hearing following prolonged work; various devices for testing the time of nervous reaction, such as the time taken to appreciate a given signal; and changes in the circulatory system.

Naturally in a new field like this one finds occasional discrepancies, but on the whole the above methods appear to have well served their purpose of indicating the approach of fatigue. The diminution in acuteness of vision and hearing at the end of a day are especially well marked. In interpreting these results it is necessary to take into account not only the actual diminution in sensitiveness, but also the power of recuperation during the night's rest. Some of the tests show a very marked progressive change in this respect during the week's work, and seem to bear out the Committee's objection to seven-day labour. They also suggest the conjecture whether, in a scientifically planned workshop, it would not be desirable to allow occasional short periods for recuperation during the working hours—a plan that was successfully tried in the United States by the late F. W. Taylor.

Fatigue in Relation to Illumination.

It is interesting at the present stage to inquire whether some method could be applied to record with precision the conditions of fatigue due to unsatisfactory illumination, and to gain evidence on the much disputed question whether some systems of lighting are less productive of fatigue than others.

The foregoing experiments appear to show that fatigue of the senses (including the eyesight) may be caused by the general conditions of work, irrespective of the special effect of labour under inadequate illumination. As far as the test of eyesight is concerned it appears incontestible that the fatigue would be greater if the conditions of illumination were such as to handicap the worker. One would therefore like to see these tests applied throughout certain trades, such as sewing, engraving, printing, &c., which admittedly make a special demand on the eyes, the conditions of illumination being varied but the skill of the operators and the nature of the work remaining identical throughout the operation. There is good reason to think that some useful evidence might be obtained through the eyesight test, but it would be surprising if, with a marked difference in the lighting conditions, it did not, to some extent, produce general fatigue, and thus also give indications by the other tests. One thing is very strikingly brought out by the above tests—the need for extending such experiments over a considerable period of time so that the effect may be cumulative. It is only when the influence of fatigue can be traced progressively throughout the period of work, and the recovery when the work ceases demonstrated, that one can feel sure of being able to draw a conclusion.

An interesting line of experiment in this connection is that undertaken by Professor Ferree in the United States, and illustrated in the recent communication by him and Mr. G. Rand at the Convention of the Illuminating Engineering Society (U.S.A.). Their results are based on the observation of the time during which type appears respectively " clear " and " blurred," when steadily looked at for a given period. We would like to have fuller confirmatory tests by observers before coming to any definite conclusions on the matter, and hope that the subject will be investigated in this country.

Such experiments obviously demand the concerted action of lighting experts and physiologists. We have seen that an actual diminution in acuteness of vision may be caused by prolonged fatigue. To an operator who suffered in this way deficient illumination would doubtless prove especially trying, and might accentuate the defects in eyesight ; for the eye, while possessing remarkable powers of adaptation to varying conditions of light and darkness, appears to recuperate very slowly, when once it has been overstrained.

But in addition, overwork appears to dull the mental perceptions, . . . to impair the power of the mind to grasp and interpret the impressions transmitted from the eye to the brain. Hence, it may sometimes happen that a fatigued operator acts as though he did not see properly, even though the mechanism of the eye appeared to the examining doctor to be quite healthy.

These instances serve to show the need for care in drawing conclusions from the examination of workmen, and especially in deciding whether the conditions of illumination are adequate or otherwise for the work in hand.

Modern Office Lighting.

New illuminants naturally give rise to new methods of illumination. The increased range of candlepower and greater efficiency of modern electric incandescent lamps has modified many problems in illuminating engineering.

For example a departure in the methods of lighting large offices and banks has come about during recent years. In the days when only carbon filament lamps were available, local lighting was regarded as essential, lamps on standards being spaced at requisite intervals along the desks, and only a small amount of overhead lighting provided for general illumination. Even at the present time some clerks prefer this old system, which has certain apparent advantages. Many people, particularly those who are advancing in years and whose eyesight is not of the best, prefer a local shaded light strongly illuminating the work but leaving the rest of the room in a comparatively subdued light. On the other hand, the installation of a large number of local lamps at intervals is tiresome and expensive, and is at once upset if the furniture is rearranged. It is also not easy to secure that the lamp is completely shaded and yet to obtain uniform illumination from a source so close to the work; and when heavy ledgers are being handled it is sometimes awkward to have a lamp or standard, liable to be knocked, so close at hand.

Until recently the substitution of a satisfactory general lighting system, instead of these local lamps was impeded by the fact that incandescent lamps of sufficiently high candlepower and efficiency were not available, and that indirect and semi-indirect lighting appliances had not been fully developed. Consequently the illumination on the work resulting from a general lighting system was sometimes insufficient, and the lamps, not being properly screened, gave rise to inconvenient shadows. In a good modern installation 4—6 foot-candles is often provided over the desks where work is done, and 3—4 foot-candles on the counters, and in view of the soft character of the lighting, this should meet requirements.

We observe among the papers at the recent Convention of the American Illuminating Engineering Society an account, by A. A. Duggin and J. B. Jackson, of a large semi-indirect installation in Chicago which seems comparable to the above. The illumination in this case was 6 foot-candles (average), and the brightness of the bowl was only 3—4 times that of the ceiling above. The installation appears to have been planned in a very thorough manner, tests of shadow-effect, deposition of dust, &c., being made as well as measurements of illumination.

It would be premature as yet to say that semi-indirect or indirect lighting is invariably best for office lighting, although having some admitted advantages. Much depends on the style and decoration of the interior, which can do much to relieve the impression of "flatness" which is sometimes ascribed to these methods. When work is only continued for a few hours this effect may not be important, but if long-continued it does seem to have a depressing influence. There is therefore room for skill in the combination of the lighting scheme with the decoration and architectural features of the room, so as to avoid flatness on the one hand or undue contrast on the other.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

SOME NOTES ON THE FIRST REPORT OF THE DEPARTMENTAL COMMITTEE ON LIGHTING IN FACTORIES AND WORKSHOPS.

(Proceedings at a meeting of the Society held at the House of the Royal Society of Arts (London), at 8 p.m. on Tuesday, November 23rd, 1915.)

THE first meeting of the Session took place on Tuesday, November 23rd, as stated above, the chair being taken by Mr. F. W. Goodenough (Chairman of Council) during the initial proceedings. The Minutes of the last meeting having been taken as read, the Hon. Secretary proceeded to read out the names of applicants for membership in the usual way.

The Chairman then called upon Mr. Gaster to give the usual summary of events during the vacation.

PROGRESS DURING THE VACATION.

Mr. Gaster remarked that in ordinary circumstances there was usually a record of useful work in connection with international congresses to be presented after the vacation. On this occasion, owing to the war, there was, unhappily, little to be said in this respect. It was, however, satisfactory to note that the Illuminating Engineering Society in the United States was continuing its work as actively as ever, and a series of interesting papers had been presented at the recent Convention at Washington.

Report of Departmental Committee on Factory Lighting.

A most important event had been the issue of the First Report of the Home Office Departmental Committee on Lighting in Factories and Workshops, on which there was to be a discussion that evening. He felt sure members would appreciate the large amount of valuable information contained in the Report which would doubtless be of considerable value to lighting engineers. He might also draw attention to the Committee appointed by the Home Office and the Ministry of Munitions, now sitting to inquire into the health of munition workers. He was glad to say that an opportunity had been afforded of bringing the claims of good lighting before the notice of this Committee.

The Proposed Increase in Postal Rates.

The suggested increase in postal rates, which was to have come into force last month, had been a matter of some anxiety to technical journals. He was glad to say that, as a result of representations to the Postmaster-General on the part of the Institute of Journalists and other bodies, there would be no alteration as far as the Journal of the Society was concerned.

It might, however, be mentioned that journals issued at longer intervals than a week were still in an anomalous position. They did not benefit by the special rates accorded to daily and weekly publications, and it seemed to him unfortunate that journals carrying out

valuable educational work for the benefit of the country should not receive these concessions. This aspect of the matter had been brought before the notice of the Postmaster-General and would, no doubt, receive his careful consideration.

Lighting Restrictions.

The restrictions on public and private lighting had been the subject of much discussion during the last few months, and almost every day references to the subject appeared in the daily and technical press. A record of some of these comments was being kept for future reference. The difficulty of interpreting many of the vague phrases occurring in some of the lighting orders, and the diversity in the penalties imposed for not carrying out these recommendations in different districts, had been recently pointed out in THE ILLUMINATING ENGINEER.

Members would recall that shortly after the lighting restrictions were introduced a Committee of the Society was formed to discuss the best method of shop lighting in war time, and some suggestions were drafted and placed before the authorities for their careful consideration, and a letter of acknowledgment and thanks had been received.

The Society had also proposed to form a Committee to deal with street lighting and offered the services of this Committee to the authorities, an offer which was renewed when the recent changes in streetlighting were being made. The offer was welcomed, but nothing further has yet transpired. The Society had also placed their services at the disposal of the Inventions Committees of the Ministry of Munitions and the Admiralty in connection with all matters relating to lighting. The Council on Industrial Research had placed the Society on their list and invited its co-operation with regard to suggestions for researches of benefit to the lighting industry.

A Gloss-Tester for Examining Glaze on Paper.

Mr. Gaster also referred to the Report of the Committee of the British Association on School Books and Eyesight, which contained an account of the gloss-tester designed by Mr. A. P. Trotter for testing and standardising the amount of shiny reflection from paper. It was interesting to recall the history of this instrument. As far back as September, 1913, Mr. J. Daniell, the Hon. Secretary of the British Association Committee, remarked on the need of such an instrument to Dr. Louis Bell, who suggested that Mr. Trotter should be consulted. Subsequently, in May, 1914, a discussion between Mr. Trotter, Mr. Haydn T. Harrison and Dr. Louis Bell took place at the editorial offices of the Illuminating Engineer, and the instrument in its present form was the ultimate result. Previous to this the question of using paper without gloss for text books had been debated in the United States, and at the commencement of the year it had been decided to print the official organ of the Society on paper of this kind Members would be interested to hear that among the journals tested by Mr. Trotter, our own stands easily first in respect of absence of inconvenient gloss.

In conclusion members would note, with regret, the death of one of the earliest Vice-Presidents of the Society—Professor Vivian Lewes, who had done so much valuable pioneering work on the incandescent mantle and other chemical problems relating to illumination,

At the conclusion of the above address Mr. F. W. GOODENOUGH invited Dr. R. T. GLAZEBROOK, C.B., F.R.S., to occupy the chair during the discussion of the Report on Factory Lighting, and Dr. Glazebrook called upon Mr. Gaster to open the discussion (see pp. 485—496) in which the following joined:—Dr. RENE SAND, Dr. JAMES KERR, Mr. W. R. COOPER, Mr. A. CUNNINGTON, Mr. C. C. PATERSON, Mr. JUSTUS ECK, Mr. LEWIS SOLOMON, Mr. E. T. SWINSON, Mr. G. CAMPBELL and Mr. F. W. GOODENOUGH.

Mr. GASTER briefly replied, and the proceedings closed with cordial votes of thanks to the author and to Dr. Glazebrook for having so kindly presided at the meeting.

It was announced that the **next meeting** would take place at **8 p.m.** on **Tuesday, December 14th,** when there would be a discussion on **Recent Developments in the Electric Incandescent Lamp, from the Illuminating Engineering Standpoint.**

SOME NOTES ON THE FIRST REPORT OF THE DEPARTMENTAL HOME OFFICE COMMITTEE ON LIGHTING IN FACTORIES AND WORKSHOPS.

By LEON GASTER.

[Introduction to discussion which took place at the House of the Royal Society of Arts (18, John Street, Adelphi, London, W.), on Tuesday, November 23rd, at 8 p.m.]

MY object in opening this discussion is to bring before the Society some aspects of the First Report of the Departmental Committee on Lighting in Factories and Workshops, and to discuss how we, as a Society, can best give effect to its conclusions and assist the work of the Committee in promoting progress in industrial lighting.

It was thought that at the present stage of the work a general discussion would be of great value both in making the aims of the Report more widely known and better understood and in suggesting possible lines of co-operation in the future.

The Report appeared at the beginning of September. It has no doubt been studied by most of these present, either in the original or in the abridged version published in the ILLUMINATING ENGINEER.* There is, therefore, no need for me to attempt to summarise its contents, and I shall confine myself to explaining a few of its main conclusions.

In doing so I should like to make it clear that I am speaking in a purely personal capacity and not as a Member of the Committee.

Preparatory Work of the Illuminating Engineering Society.

The issue of the Report is the culmination of a great deal of steady work on the hygienic aspects of lighting which has been done during the last few years. It would take too long to enter into the history of this movement fully, but those interested will find a summary in the editorial in the official organ of the Society for September.* I feel sure that any one who studies that account will recognise that the appointment of the Committee was not in any sense a sudden decision, but the result of years of methodical work. I am not one of those who expect sudden results or immediate solutions of great problems. The history of our movement has shown that the best results are obtained by persistent and steady effort and by the patient education of public opinion; and that it is invariably unwise to try to rush through things quickly in the teeth of misunderstanding and strong opposition. The most stable organisations are of slow growth.

The work of our Society since its foundation in 1909 has brought about a great change in the public standpoint in matters of illumination. Ten years ago little appeared in the press on lighting matters and such articles as were published usually dealt exclusively with the comparative costs of rival systems of illumination. It has been part of our work to raise other important issues of common interest to representatives of all illuminants, to encourage people not to think only of their expenditure on lighting, but to recognise that lighting is always uneconomical unless it carries out the purpose in view. In particular our Society can take credit for having done much to establish the value of good illumination in the interests of health, and as a practical necessity for the carrying out of work in safety and comfort.

Previous Investigations on Industrial Lighting.

Naturally, this aspect of lighting has been largely responsible for the appointment of the Committee. The need for our investigation was justified by investigations carried out by the Factory Department of the Home Office for several years, much of which has appeared in the Annual Reports issued by H.M. Chief Inspector. In addition

* *Illum. Eng.*, Sept., 1915.

the hygienic aspects of lighting in relation to industry were prominently brought forward at two most important recent international congresses, the Congres International des Maladies Professionelles, held in Brussels in 1910, and the First International Congress for the Prevention of Industrial Accidents, held in Milan in 1912, at both of which I was present as a delegate from the Illuminating Engineering Society. Shortly after the Brussels Congress a Committee with similar functions to our Departmental Committee was appointed by the French Government, and the American Illuminating Engineering Society has also been active in studying the subject and in encouraging appropriate legislation on the part of the various States.

Legislation of other Countries on Factory Lighting.

The outstanding fact by which our Committee was faced was the absence of any general provisions in respect of lighting, analogous to those regarding temperature and ventilation, in the Factory Acts of the United Kingdom.

One of the most valuable sections of the Report is that in which a summary is made of the legislation bearing on industrial and school lighting in the chief European countries and in the United States of America. Many of these regulations were introduced a number of years ago; it will be seen that in most cases these are of a very general character, and in the light of the experience acquired during the last few years it is now possible to aim at greater precision in the definition of terms used (such as the meaning of adequate and suitable lighting). It need scarcely be said that the work carried out by the illuminating engineering movement since the formation of the Society has been of the greatest value in paving the way for this investigation. The facility with which measurements of illumination can be made has been much increased, the essentials of good lighting have been discussed in many aspects, and the ideas of authorities on debatable points in illumination have been greatly clarified. One other special result of this work has been the bringing about of a general recognition that illumination cannot be satisfactorily dealt with by engineers alone, but that the co-operation of other experts, physiologists and architects, physicists and the general public is needed. This is now generally recognised. The French Government, in forming their Committee in 1911, took care to secure the services of these various experts. The Departmental Committee includes among its members physicists, physiologists and engineers, and in receiving evidence every effort was made to secure representative views from architects, managers of factories, employers and employees.

I venture to think that the result has been a unique publication of which this country has reason to be proud. It is no exaggeration to say that in no other country has there been any Government publication on industrial lighting which can compare in respect to completeness and the amount of work done. At the present time such an investigation is a necessary preliminary to legislation. In most other countries enactments on lighting have been the work of a Government official, sometimes acting on the advice of engineering experts, and in these circumstances it was naturally only possible to deal with the subject in the briefest and most general manner.

Distinction between Official Government Report and Treatises by Societies and Individuals.

I would next like to deal with a point on which there has been a little misapprehension, the special conditions which necessarily limit a Government Committee. The preparation of an Official Report, to be regarded as a preliminary to legal requirements, imposes a special responsibility on the members of a committee. Its conclusions carry a weight which the suggestions of individual experts or even societies do not; and it must, therefore, be particularly careful to avoid giving expression to views which are not thoroughly authenticated, and to explain its recommendations in the clearest possible terms. While the information given in the Appendices of the Report is chiefly of utility to people who are more or less experts on lighting, the body of the Report must be so drafted as to be intelligible to the general public and particularly to those who are concerned

with the legal aspects of it, but are not necessarily experts on illumination.

For this reason the terms used in the Report have been defined more fully than would, perhaps, be necessary for members of our Society, and it was frequently necessary, as a justification of the conclusions, to make statements which we, as a Society, may regard as truisms, but which those unfamiliar with matters of illumination would not.

This point may be illustrated by a comparison with two other valuable contributions to the study of industrial illumination, the "Code on Factory Lighting" issued by a Committee of the American Illuminating Engineering Society last September, and the booklet on "Industrial Lighting" issued by the National Electric Light Association in the United States in 1912.

The Code is a most useful publication. Properly regarded it confirms in almost every respect the recommendations of the Departmental Committee, but the fact of its not being an official Government publication enabled its compilers to put forward certain data (such as the illumination desirable for various classes of general work) which our Committee preferred to leave open for further and fuller investigation. As a publication sanctioned by the American Illuminating Engineering Society, however, the Code carries considerable weight and imposes on its compilers some responsibilities. It has, therefore, not attempted to enter into more debatable matters, such as a detailed survey of the conditions of illumination required in a large number of technical operations. The Code was prepared presumably for the guidance of those engaged in arranging the lighting of factories, and is illustrated by a few typical examples showing the advantages of good illumination.

The booklet on Industrial Lighting is again of a different character. It does not profess to apply to all systems of lighting, but only to illumination with electric lamps, and it was not issued by a Society, but by a commercial organisation. It was, therefore, practicable to give much more detailed instructions with regard to lighting for various industrial operations and to prescribe the actual lamps and type of reflectors used in each case. The book is intended as a lighting specification, and its recommendations represent standard practice. It would, of course, be admitted that in many of these cases there is room for discussion and that, as new types of lamps and fittings are introduced, some of the recommendations would become obsolete. As a guide to industrial illumination it contains much useful information, but the suggestions are admittedly tentative, and at the present time it is clearly impracticable to introduce legislative requirements on such a detailed plan.

Chief Points of Interest in the Report.

From the standpoint of our Society it may be suggested that the chief points of interest in the Report are :—

(1) The recommendation that there should be statutory provision :—

(*a*) requiring adequate and suitable lighting in general terms in every part of a factory and workshop, and

(*b*) giving power to the Secretary of State to make orders defining adequate and suitable illumination for factories and workshops and for any parts thereof or processes carried on therein.

(2) The recognition of the value of good illumination as desirable in the interest of the safety and general health of workers, and as an important factor influencing the output and quality of work.

(3) The actual record of work done contained in the Appendices comprising data and measurements obtained in many factories, supplemented by the general impressions of the observers; and the summary of the requirements as regards lighting in the chief European countries and the United States.

As our knowledge regarding the requirements of good lighting increases, we find that recommendations become more precise and explicit. It is of interest to notice that the latest Indian Factory Act, 1911, makes a special reference to lighting as follows :—"(1) Every factory shall be sufficiently lighted; (2) In the case of any factory which is not in the opinion of the inspector so lighted, the inspector may serve on the manager of the factory an order in writing specifying the measures which he considers necessary for the

attainment of a sufficiently high standard of lighting, and requiring him to carry them out before a specified date."

It may be suggested that, with a view to avoiding misunderstandings, recommendations of this kind should preferably be supported by fuller instructions as to what constitutes good lighting. In the recently issued Report it should be particularly noted that "adequate and suitable lighting" is defined, not as involving only the provision of a certain amount of illumination, but also as implying satisfactory conditions in regard to the avoidance of glare, inconvenient shadows, &c. The recommendations of this Committee are unique in that they are the result not only of evidence tendered by a very varied set of witnesses, but of personal experience and a very exhaustive series of tests undertaken by the Committee. Some idea of the work entailed may be gathered from the data so far published but it should be remembered that there is still another volume to come, which will contain a detailed account of the lighting conditions in each factory visited, the measurements of illumination, and the personal impressions of the Committee thereon. These data should certainly be of considerable value as showing the actual conditions of illumination prevailing in the classes of factories visited.

Besides its manifest utility to the general public the Report should be much appreciated by the lighting industry since it provides a definite and official recognition of the importance of lighting, which should be of great value to all who are engaged in working for the improvement of industrial illumination. I venture to think that this broad view of the utility of the Report is one which should commend itself to the Society; and that in comparison the possible bearing of its conclusions on the applications of this or the other illuminant is of secondary importance.

With a view to ascertaining possible points for discussion I have taken some pains to examine the comments on the Report in various journals interested in lighting matters which have been brought before my notice. Some of these views are presented in tabular form. The list of journals is not in any sense complete, but from those so far examined it is evident that the value of the Report is appreciated in a great variety of papers dealing respectively with engineering, hygienic and architectural matters. [This list includes, among others, the following:—*American Gaslight Journal, Architect, Electrician, Elec. Engineering, Elec. Industries, Elec. Review, Elec. Times, Engineer, Engineering, Gas World, Hardwareman, Illustrated Carpenter and Builder, Journal of Gaslighting, Lancet, Sanitary Record, Times Engineering Supplement.*] (See pp. 490—491.) I would like to draw attention to one enterprising step taken in the issue of the Report, namely, the publication of a four-page Memorandum, summarising the chief points of interest and giving the essence of the material contained therein. An abstract of this kind is a great aid to journalists when reviewing a bulky Government Blue Book, and it is also desirable in the interest of the Department by whom the Report is issued as it ensures that the chief objects of the publications are not lost sight of in a mass of detail. It is interesting to see that most of the journals that have commented on the Report have made use of this Memorandum. I believe that the issue of an explanatory Memorandum is a new precedent in connection with Government publications, and I venture to suggest that it might be followed as a matter of routine by other Departments in the future, as it supplies a much-needed bridge between highly technical but valuable official information and the general public.

Anyone reading the Report must be struck by the special pains taken by the Committee to render its contents easily understood, and to make it clear that its provisions are presented as a service to the public, and not in any sense as a hardship to manufacturers. I think that a perusal of the evidence will also show that the Committee have been most anxious to hear the views of all those interested in various aspects of illumination, and that they have lent a willing ear to suggestions. Doubtless the Committee would be only too glad to hear suggestions as to further work which would be beneficial, and it may be hoped that this friendly discussion will lead to fruitful results in this respect.

Some Points for Discussion.

The reception of the Report in the Press has been, almost without exception, friendly, and in the one case in which its contents have clearly been misinterpreted and under-valued, it is not difficult to trace the motives of the writer.

In dealing with some of the comments that have been made, therefore, I do so merely in order to clear up a few evident misunderstandings.

(1) In a few cases it has been suggested that the Report contains a needless amount of explanatory matter and even truisms in regard to illumination. On this point something has already been said. It has been pointed out that explanations which appear needless to a lighting engineer may be highly necessary to the general public, for example, to backward manufacturers who have not thought much about lighting matters. Moreover, if a statutory requirement of adequate and suitable illumination is made and penalties are eventually imposed, the precise definition of "adequate and suitable" illumination becomes an important matter; the contents of the Report will form the leading guide as to what is meant by this term, and must therefore be framed to meet all such contingencies. Moreover, factory inspectors have not previously been entitled to take general action in regard to defective lighting, and they will have to proceed cautiously and to gain their own experience; for their guidance full and explicit information, even on apparently elementary points, will be very helpful.

(2) A few writers, particularly those who are accustomed to deal with lighting matters, and have therefore some knowledge of the order of illumination met with in modern up-to-date factories, have been disposed to think that the minimum values suggested are too low; or to question the principles on which they are arrived at. I need scarcely say that these values were not put forward without long and careful consideration. The aim of the Report is to avoid at all costs, recommendations which might subsequently be found to be too burdensome, and to involve unnecessary hardship to manufacturers. When taking an entirely new departure this is always a sound principle to work upon. One has to strike a balance between what is desirable theoretically and what is practicable. The researches of physiologists have shown that in general a marked diminution of acuteness of vision begins when the range of illumination is reduced below the range of values specified in the Report; yet one's impressions in this respect depend very much on the state of adaptation of the eye and the success with which glaring points of light are avoided. In any case such estimates have to be considered with respect to the conditions actually found in practice. It is not enough to specify what is theoretically desirable, one must make sure that what one desires can be actually carried out. The estimate was therefore checked by a very laborious series of measurements in many factories and the "frequency of occurrence" curves presented in the Report gave a clear guide as to the values which might be expected without hardship in factories at the present time. I may say that the minimum value prescribed in factories—0·25 foot-candles—has been independently arrived at in other investigations. It is, for example, the minimum value found on the platforms of railway station platforms* (where the safety and general convenience of passengers is the chief consideration determining the illumination), and it was independently suggested years ago as a result of investigations in the United States.†

It must also be recognised that these values are not average but "practical legal minimum" values. I notice that this distinction is emphasised in the American Code on lighting. The *minimum* foot-candle intensity is fixed (quite independently) at 0·25 foot-candles for storage, passages, stairways and the like, but the *desirable* foot-candle is placed somewhat higher, namely, 0·25—0·5 foot-candles; the latter value is not far from the actual minima met with in our investigations and recorded in the "frequency of occurrence" curves.

It need scarcely be said that with modern illuminants there is usually a

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* See discussion before this Society, *Illum. Eng.*, Jan., 1912, pp. 26, 35.

† Resume of Legislative Enactments on Illumination, E. L. Elliott, Trans. Ill. Eng. Soc. (U.S.A.), Oct., 1911, p. 738.

TYPICAL COMMENTS ON THE REPORT IN TECHNICAL JOURNALS.

Journal.	Date.	Space (cols.) devoted to		View expressed.	Remarks.
		Comment.	Reproduction.		
Am. Gaslight Journal	Oct. 25	2		Favourable	*Architect.*—Recommendations do not err on side of severity. Relation between illumination on working area and non-working areas (avoidance of excessive contrast) seems to have escaped notice.
Architect	Sept. 17	2½		Favourable	
Electrician	Sept. 20	three-quarters	3	Favourable	*Electrician.*—Committee have wisely contented themselves with general recommendations. Importance of material illuminated. 0·25 ft.-c. seems low, but minimum rather than standard practice. More attention should be devoted to glare. Report marks an advance which should be appreciated by all workers in factories.
Elec. Eng.	Sept. 16		1	—	
Elec. Industries ..	Sept. 15	4		Favourable	*Elec. Industries.*—Appointment of Committee a proof of intelligent foresight. Enormous amount of munition work justifies recommendations on lighting.
Elec. Review ..	Sept. 17	one-half		Favourable	*Elec. Review.*—Publication of results so far reached wise. Problem very complex. Recommendations only affect bad cases of factory lighting. Appendices of great value.
Elec. Times.. ..	Sept. 9	1½		Unfavourable	*Elec. Times.*—Objection is taken to the impartial tone of the Report in regard to illuminants and it appears to be implied that electric lighting should have been advocated.
Engineer	Sept. 10	1½	1¼	Favourable	*Engineer.*—Importance of definition of "adequate and suitable." Actual measurement of illumination now as easy as measurement of temperature, but decision on minimum standard difficult. At present shop-lighting is provided on a generous scale because it is clearly recognised that parsimony in this matter is false economy indeed. But lighting arrangements are not planned with a photometer because no one can calculate beforehand how much light will be required and how much will be obtained by any suggested arrangement. By all means let the factory inspectors have power to demand adequate lighting. It is urgently required in not a few shops. But let the determination whether the lighting is adequate and suitable rest with the worker and the factory inspector's experience and general impressions, and not upon photometric measurements and legal minimum standards which cannot be made justly applicable to more than a few isolated sets of conditions.
Engineering ..	Sept. 10	2		Favourable	*Engineering.*—Report of service in view of large amount of munition work going on. An absolutely new departure. In respect to data collected the Report is admirable. Adequate lighting difficult to define but the Report makes no effort to evade the matter. Accident curves erratic, and, except in case of persons falling, doubtful.

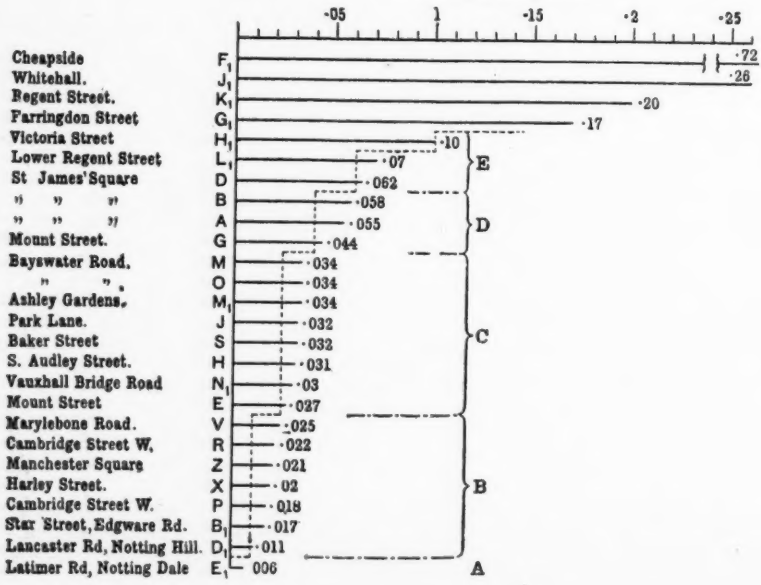
Gas World	Sept. 11	one-third	5	—	*Gas World.*—Very valuable Report. Will be of great utility as a support to those trying to improve lighting in factories. Plain English, simple arithmetic, and lucid explanation, are good features. When one compares the pages of the Report in which technical terms are explained with text of similar import in the usual technical books and papers the difference is quite remarkable. Every gas supply officer should get its main conclusions by heart.
	Sept. 18	three-quarters		Favourable	Writer expresses entire disagreement with *Elec. Times.*
Hardwareman ..	Oct. 28		one-half	—	
Illustrated Carpenter and Builder ..	Oct. 29	$1\frac{1}{4}$		—	
Journal of Gaslighting	Sept. 7	one-half	$6\frac{1}{2}$		*Journal of Gaslighting.*—Thorough and persistent work in an entirely new and difficult field. All agree as to importance of good factory illumination. Not much said as to ill-effect of bright light on the eyes. Doubtful if factory owner will dabble in measurements of parts of a foot-candle.
	Sept. 14	$2\frac{1}{2}$	$1\frac{1}{2}$		
	Sept. 21		$1\frac{1}{4}$		
	Sept. 28		$2\frac{1}{4}$	Mainly	
	Oct. 5		$2\frac{1}{4}$	favourable	
	Oct. 12		2	but some	
	Oct. 19		2	criticisms.	
	Oct. 26	one-half			
	Nov. 2		3		The time is distant when exact standards can be prescribed but if the work of the Committee produces improvement without absolute standardisation good will have been achieved. Definition of adequate lighting loose and uncertain. 0·25 ft.-candle too low and 0·05 in open spaces (*e.g.*, in railway yards, etc.) absurd. In fine work local lights should be regulated to suit the eyesight of workers. Nat. Phys. Lab. experiments not applicable to factory conditions owing to absence of vibration, smoke, etc. Effect of colour of material shows that no general standard is practicable. Indirect lighting for most workroom operations unsatisfactory.
					Report opportune as stating the case for good factory lighting, now that so much munition work is being done at night. Gas undertakings, armed with the Report, can bring this point home.
					(Other comments imply that the merits of gas lighting, in certain directions, have not, in the writer's opinion, been sufficiently emphasised.)
Lancet	Oct. 9	2		Favourable	*Lancet.*—Everyone feels a difference in spirits if the day is dark and gloomy instead of bright and sunshiny, and this difference makes a measurable effect in terms of practical efficiency. Chief past obstacle the measurement of illumination now overcome. The fact that only 2—10 per cent. of natural light is admitted, even in best lighted factories, seems remarkable. Statements in regard to eyestrain confirm what is known or generally assumed to be true. Medical men will welcome the Report.
Sanitary Record ..	Oct. 8	one-half		Favourable	*Sanitary Record.*—To attempt to work in half or ill-lighted rooms involves intense strain on the eyes and affects the nervous system. At once the productive power of a person is impaired.
Times Eng. Supplement	Sept. 24			Favourable but some criticisms	*Times Eng. Supplement.*—Report a confirmation of best official opinion rather than anything fresh. Statements regarding effect on output and the prevention of dirt useful. But Report needlessly filled with truisms, *e.g.*, (1) and (2) in definitions of adequate lighting and also advice in regard to daylight being preferable to artificial light.

considerable variation in the illumination furnished at different points in the room, so that a minimum of 0.25 foot-candles at one point means that the illumination at most other parts of the room will be very much higher. Above all it must be clearly recognised that these are values in the interests of safety and convenience merely, and that in almost all cases the necessity of providing suitable illumination for the work carried on will in itself go far towards providing higher minimum values.

I think therefore that it will be conceded that the 0·25 foot-candle value has justification. But even so there will occur certain cases, particularly very large rooms and open spaces, where even this value could not be obtained without an unreasonably great expense. The Committee have therefore considered such open spaces separately and fixed lower minimum values, and have also inserted an exemption clause to meet hard cases. As regards the illumination in large open spaces, docks, &c., I think that few of those who have seen these large areas in practice will question the advisability of being very lenient in fixing a minimum value. I notice that in one journal the suggested value of 0·05 foot-candles in such areas is spoken of as absurdly low. On the contrary I, personally, would have doubted the wisdom of asking even this value were there not the exemption clause as a safeguard. The conditions in such cases are utterly different from those encountered in an interior. There is no material gain of light by reflection from surroundings, and the lamps have to be spaced so far apart that the variation in illumination is necessarily very large. The best analogy is supplied by the full data available on the pre-war lighting of London's streets, so ably dealt with in Mr. Trotter's paper before this Society in 1913.* 0·05 foot-candles is about the value met with in St. James's Square, while in the Marylebone Road and in Cambridge Street there was only half this value. This is illustrated in the following diagram, taken from Mr. Trotter's paper :—

* Standard Clauses for Inclusion in a Specification on Street Lighting, by A. P. Trotter, *Illum. Eng.*, Vol. VI., 1913, pp. 250, 251.

Minimum Illumination in foot-candles received on a horizontal plane 3 ft. 3 in. from the ground.


·05
1
·15
·2
·25
Cheapside F1 ·72
Whitehall. J1 ·26
Regent Street. K1 ·20
Farringdon Street G1 ·17
Victoria Street H1 ·10
Lower Regent Street L1 ·07 E
St James'Square D ·062
" " " B ·058
" " " A ·055 D
Mount Street. G ·044
Bayswater Road. M ·034
" " O ·034
Ashley Gardens. M1 ·034
Park Lane. J ·032
Baker Street S ·032 C
S. Audley Street. H ·031
Vauxhall Bridge Road N1 ·03
Mount Street E ·027
Marylebone Road. V ·025
Cambridge Street W. R ·022
Manchester Square Z ·021
Harley Street. X ·02 B
Cambridge Street W. P ·018
Star Street, Edgware Rd. B1 ·017
Lancaster Rd, Notting Hill. D1 ·011
Latimer Rd, Notting Dale E1 006 A

In order to illustrate the great variations which occur in ordinary street lighting, it is of interest also to recall the following figures (from the same source):—

Street.	Illumination on a horizontal plane 3 ft. 3 in. from the ground. Foot-candles.		Max./min.
	Min.	Max.	
St. James Square	·055		
,,	·058	1·86	32
,, (7.25 P.M.)	·062		
Mount Street	·027	0·86	24
,,	·044		
S. Audley Street	·031		
Park Lane (8 P.M.)	·032	0·60	19
Bayswater Road (9.45 P.M.)	·034	2·28	67
,,	·034	1·79	53
Cambridge Street	·018	0·63	31
,,	·022		
Baker Street	·032	1·24	
,,		0·68	18
Marylebone Road	·025	0 ·60	24
Harley Street	·020	0·37	18
,, Manchester Sq.	·021	0·54	26
Lr. Berkeley Street			
Star Street, Edgware Road (11.40 P.M.)	·017	0·83	49
Lancaster Road, Notting Hill	·011	0·53	48
,, Latimer Road, Notting Dale	·006		

The well diffused illumination from a full moon in a clear sky, about 0·02 foot-candles, is regarded as a very useful degree of light for outside operations, so far as safety is concerned, so much so that in other countries where the climatic conditions are more regular street lamps have been dispensed with on moonlight nights. It may, of course, be said that in many industrial operations there are points where special danger is incurred, *e.g.*, where trucks are passing or where there are risks of stumbling over obstacles and falling a dangerous height. But in such cases the general requirement of adequate lighting would come into force, and if there was obvious danger an inspector would be justified in recommending special measures at these points of work, such as the use of portable lamps, the whitening of surfaces to mark the demarcation from the dangerous zone, &c.

(3) A desire has been expressed that something more definite should be said on the subject of glare, and that a provision limiting the contrast between the illumination on the work and of surrounding parts of the workroom should be inserted. As regards the avoidance of glare I think the Report is sufficiently emphatic. At the present stage it is hardly practicable to include in the body of the Report hard and fast rules for its avoidance, as these necessarily differ so much according eo the nature of the workshop; such precautions should, however, be studied by inspectors and applied by them in giving advice as to how a tendency to glare might be remedied.

As regards the avoidance of excessive contrasts in illumination this is met by two requirements. *Firstly*, by the general requirement that there should be a reasonable constancy of illumination over the working area; *secondly*, by the fact that the minimum general illumination is 0·25 foot-candles. According to Weber there is no impression of glare provided a contrast exceeding 100 : 1 in brightness is avoided; and even this ratio would perhaps be difficult to adhere to in practice. However, a ratio of 100 : 1, with a minimum illumination of 0·25 foot-candles, would permit of an illumination of 25 foot-candles on the work, which is only required in very exceptional cases.

(4) A few critics of the Report have suggested that some more definite information should be given under the heading "how to light a factory"; in other words that some form of specification should be prepared stating the amount of illumination for various processes and the desirable arrangement of lamps, &c.

It is explained in the Report that the specification of the illumination for the purpose of carrying out work has not

yet been sufficiently studied to justify us in putting forward definite values. Those who speak light-heartedly of brief and "practicable general schemes" of factory lighting can scarcely have studied the subject in any detail, and can have no idea of the innumerable complex factors affecting the conditions of illumination in various industries. Ideas on this subject can only become crystallised by gradual experiment and discussion in co-operation with those engaged in the respective industries, and it would certainly be foolhardy at the present moment to attempt to make such values a basis of legal action.

On the other hand those who accept the principle of the general recommendations in the Report and supplement this by a study of the data in specific factories presented, are already in a position to make substantial improvements in the more backward factories in regard to lighting, and this is surely a great point gained. Moreover, the introduction of new methods of lighting and improved illuminants keeps the subject in a constant state of flux and the values considered ample a few years ago are no longer accepted to-day. As an illustration I may mention that Holland, which a few years ago drafted a series of requirements for the lighting in certain industries, has recently found it necessary to double the original values.

I mention these facts to give an idea of the difficulty of including requirements of this kind in official recommendations on factory lighting. At the same time there is every reason to advocate unofficial investigations by experts on various problems in factory lighting, and our Society can, and I hope will, continue to add to the good work it has already done in this respect. The leading manufacturers of lighting appliances, too, are already doing excellent service in standardising requirements for their particular lighting appliances. The issue by the National Electric Light Association of the booklet on "Industrial Lighting" has already been quoted as an excellent piece of work of this kind.

(5) I notice in one article on the Report the following passage:—

"At present shop-lighting is dictated on a generous scale in every up-to-date factory, because it is clearly recognised that parsimony in this matter is false economy indeed. The lighting arrangements are not planned with the aid of a photometer because no one can calculate beforehand how much light will be required and how much will be obtained by any suggested arrangement."

I have indicated above the complexity of the problems determining the illumination needed for various processes, but I venture to think the above statement exaggerates the difficulties. While it is doubtless true that experience, aided by measurements of illumination to serve as a record, is needed to fix the conditions of illumination required, there is no doubt that one can form a very fair idea of what is necessary, and in some trades the requirements are already becoming fixed within practical limits. It is also a fact that the systems of lighting recommended by up-to-date firms concerned with lighting are based on photometric measurements; there is no serious difficulty in determining beforehand, quite closely enough for practical purposes, the order of illumination which will result from lamps of a certain candle-power, equipped with standard forms of reflectors and located in predetermined positions. The evidence of several witnesses quite bore out this view.

(6) The statement that daylight is in general preferable to artificial light, and the advice to make the best use of daylight illumination on this account, have been regarded as a truism. If so, this is a truism that those responsible for planning admission of daylight would do well to bear in mind, for insufficient window-space is a not infrequent fault, especially in old-fashioned factories. The matter has also a special bearing on basements, and it is an arguable question whether insufficient daylight should be supplemented by artificial light, or whether daylight should be completely excluded before artificial light is used. The transition from daylight to artificial light needs careful handling and there is ground for thinking that accidents are particularly liable to happen at this period of the day. It has even been suggested that for reasons of health, basements which require constant artificial light should not be used as factories and workshops.

However, the whole question of daylight illumination is a most complex one, and would require in itself a separate evening's discussion. I must content myself on this occasion with pointing out the exhaustive data on this subject contained in the Report, which should be most useful to architects and engineers concerned with the construction of factory buildings.

(7) Finally, I may mention a few criticisms based on the impression that the merits of one or another illuminant have not been sufficiently emphasised As I have indicated above, I regard these disputed points as of secondary importance in comparison with the aim of studying factory lighting as a whole and bringing about an improvement in the manner in which the illuminants are used.

Broadly regarded, these criticisms cancel one another, in one case the objection being raised that some advantage of electric lighting has not been pressed, in another the wish expressed that some merit of gas lighting had been more emphasised. I venture to think that keen partisans of particular illuminants do not sufficiently realise how greatly these presumed advantages depend on the local circumstances, and how frequently some apparent drawback is due not to any intrinsic defect in the illuminant so much as the unsatisfactory manner in which the illuminant is used. Members of the Society will agree that it is far better to aim at constructive work of value to the public and the industry as a whole, than to embark on controversial side-issues which merely accentuate points of difference.

Suggestions for Future Work.

There is room for detailed and systematic study of the requirements in regard to lighting in specific industries and no doubt this important piece of work will be undertaken in course of time. It is, however, work that obviously requires very careful treatment and one cannot expect immediate results. In view of the large number of factories working overtime on Government contracts the present moment was considered opportune for the issue of a Preliminary Report summarising the work so far undertaken and this, in itself, is surely a creditable result of two years' work.

There have naturally been some points on which evidence was less easily gathered than others and I would like to refer to several particular lines of investigation which would be helpful. One of these is the effect of inadequate illumination in causing eye-strain or general fatigue. While there is a very general recognition that inadequate lighting is detrimental to the health of workers, it is at present difficult to get sufficient evidence of actual cases, merely because no complete investigation of the matter has yet been undertaken. It is obviously a matter in which the co-operation of the physiologist and the oculist is necessary and in future we ought to study out some way in which the records of eyesight, nervous breakdown, &c., recorded by such specialists can be correlated with the lighting conditions which the sufferer has been experiencing. Only by slow systematic work of this kind can we hope to gradually trace the connection.

The physical condition of workers is of great importance at the present moment and a Departmental Committee under the auspices of the Home Office and the Minister of Munitions has recently been appointed to deal with the subject. An opportunity of bringing before their notice the relation between inadequate lighting and fatigue was recently afforded and no doubt they will consider the work of the Departmental Committee in the course of their researches and in framing their recommendations.

There seems at present to be a need for some general method of testing fatigue of eyesight. Experiments in this direction have been undertaken in the United States, but it is obvious that in studying different systems of illumination the variety of test imposed must be very carefully considered. Perhaps some of our members who are physiologists may be able to furnish some suggestions on this matter. One point seems to me clear; namely, that any such tests should take into account the time-element, *i.e.*, should be applied not at irregular intervals, but over a continuous period so that any fatiguing effect characteristic of the lighting system has time to make itself felt.

Another line of investigations which perhaps offers even greater immediate prospects, is the study of the connection between illumination and output and quality of work. One constantly hears of incidents illustrating the close relation between illumination and work accomplished, and several of the witnesses were able to mention actual instances of a measured gain in output and quality being observed when the conditions of illumination were improved. It is, however, difficult, particularly in the present circumstances, to induce manufacturers to consent to experiments on this point. It would be most useful if those of our members who are constantly dealing with industrial lighting installations were to begin to make a study of this matter and to collect as much evidence as possible on this economic aspect of good illumination. Certainly, in the future, it would prove one of the most powerful appeals to manufacturers if such statistics could be collected.

Some of you have doubtless heard of the wonderful results accomplished in the United States by the late Frederick Winslow Taylor, how by patient study of details, by watching industrial operations day by day, he was able to correct little deficiencies and to economise labour until the output in a given time was actually doubled or trebled. I have often thought that a similar method of watching and timing industrial operations could be usefully applied to lighting problems. Something of the same kind was undertaken by Mr. Thurston Kent in the United States some time ago. It need scarcely be said that in such work, as in experiments on fatigue, it is very important to secure comparable conditions when two systems of lighting are compared. The workers throughout must be engaged on precisely similar operations and of equal skill.

All these are lines of investigation which might very well be taken up now that the Report has brought before the public mind the value of good illumination. If it only served to pave the way for such experiments the Report would prove a most useful piece of work, but I think that, in itself, it already furnishes much useful information to lighting engineers. This, indeed, is one piece of work in which this country may be said to have taken the initiative and to have been in advance of the rest of Europe. The same might truly be said of the Illuminating Engineering Society. The present war has brought home to us many remarkable features of German organisation and enterprise. It is of interest to point out that in this respect we took the lead and that, when some years ago, a society with similar aims to our own was formed in that country, the Reichsanstalt applied to us and obtained all the necessary information and guidance as to the method of conducting the illuminating engineering movement in England.

The great feature of our work, the opportunities it affords for common action between various experts and representatives of different systems of lighting, has surely proved its value to the lighting industry during the last six years, and I am sure we all recognise the importance of sinking any little rivalries and differences of interest that may exist and working shoulder to shoulder for the common good. Light is a necessity and not a luxury, and even in time of war it is necessary—perhaps even more necessary than in time of peace—to ensure that it is wisely employed. England has for long been justly regarded as the home of industrial hygiene, and our Society owes a debt of gratitude to the Home Office for the judicious and energetic manner in which they have taken industrial illumination under their wing. I think that I express the views of the members of the Society in emphasising the great services which H.M. Chief Inspector, Sir Arthur Whitelegge, has rendered to the study of the hygienic aspects of industrial lighting, and the importance which he has attached to good illumination, in several Annual Reports. Special thanks are also due to the Chairman of the Committee who has devoted so much time and care to these researches.

DISCUSSION.

Dr. R. T. GLAZEBROOK (chairman) said that the position was perhaps rather a novel one. The report which was to be discussed was the first report of the Committee, which was still in the middle of its work. There was a great deal to do, but by this time a great deal more would have been done had it not been for the position created by the war. The work carried out by the Committee had been of very great interest in very many ways, and the object of the discussion that evening was to gain information from the members of the Society which would be beneficial to the Committee in its future work. An inquiry of this kind which endeavoured to inquire into the conditions most favourable for work, and the conditions disadvantageous for work, and the laying down in general terms of the requirements for good work so far as illumination and eyesight were concerned, was one which must be fraught with great value in the future.

Dr. RENE SAND (*late Assistant Professor of Pathology in Brussels*) expressed his thanks for the kind reception given him by the Society. He had followed the work of the Society in this connection with great interest since the Brussels Congress, in which Mr. Gaster and Dr. Legge, of the Home Office, took such a prominent position. He had observed with great pleasure the resolution of the Belgian Academy of Medicine, urging the Belgian Government to take some steps on this question of factory and workshop lighting. He hoped, after the war, the Belgian Government would start to work energetically on this question and would find valuable data in the work already accomplished by this Society.

Dr. J. KERR said it seemed to him that the further work which must develop out of the Committee's report would be questions of fatigue and eyesight. The question of glare was extremely important, because it was not merely the illumination that affected the individual, but also the individual who had to re-act to the illumination. A good many years ago he had to do with printers who were working on the new linotype machines, who complained that they could not do the work because they could not see the line of letters on the little block of metal, owing to it being so shiny. Inquiries showed that these men were smokers, and that they had a slight degree of tobacco amblyopia. By leaving off tobacco, however, it was possible for these men to get to their work again without disturbance from haze and glare. This question of the condition of the individual was an important one, and the production of after images, as Mr. Gaster had pointed out, was also to be considered in the case of combined daylight and artificial lighting. The report also dealt with the intrinsic brightness of the source of light, another thing of great importance from the after image point of view. These were the points which had appealed to him in reading through the report.

Mr. W. R. COOPER said he was glad the Committee had taken up the point of view of the comfort of the workers, which was a very important matter. Recently he had been looking at the new car inspection sheds of the London and South Western Railway Company at Wimbledon, and was interested to see that these open sheds were all heated so as to have things as comfortable as possible during the winter. There was no question that the best work could only be obtained under reasonably comfortable conditions. If the idea of consideration for the workers had been grasped by employers many years ago, much trouble would have been saved.

A point to be emphasised was the money value of good illumination, and if the Committee could get more instances of that, it would be an advantage to publish them. He could not help thinking that 0·25 ft.-candle as a minimum for workroom illumination was a bit low, and if the Committee could see their way to raise it, it would be an advantage. Perhaps this was going a little too fast and must be postponed for the future.

In any case it seemed to him that the term "workroom" was too vague at the present moment. Surely there must be great variations between one room and another, and he thought this question might have been taken up a little sooner than waiting for a further report. A workroom containing machines in an engineering factory must differ very materially from a workroom containing looms in a textile factory, more particularly for different materials under manufacture.

He did not know whether any reference had been made in the report to the exposure of the eyes to the source of light. If it could be done it would be a great advantage to call attention to the undesirability of exposing metal filaments to the eyes, *i.e.*, by using clear glass bulbs. Many people did this without hesitation, and the risk from it would become still greater when the half-watt lamp came into greater use. He thoroughly agreed with Mr. Gaster as to mixed light. A mixture of artificial light and daylight must always be exceedingly trying for the sight, and light of that sort should be avoided at all costs. Either have daylight altogether or artificial light altogether. He regarded the work that had been done as most valuable and the report itself as a step in the right direction.

Mr. A. CUNNINGTON (London and South Western Railway), as a practical worker in illumination, welcomed the results published by the Committee. The frequency of occurrence curves, summarising the readings of illumination in various factories, were especially interesting and altogether a new departure. It would appear from the report that the Committee in arriving at their conclusions made more use of actual measurements than of the expressed opinions of the witnesses, and undoubtedly this was the right course, for general impressions—even of people accustomed to dealing with lighting problems—were sometimes rather vague.

One or two figures suggested by witnesses in the minutes of evidence seemed wide of the mark. For example, one of the witnesses had suggested 2 ft.-candles as the *minimum* for corridor lighting. Directly one came to work this out one saw it was impracticable. He had prepared a diagram (Fig. 1) showing corridor lamps 8 ft. above the floor and 17·3 ft. apart. In order to get a minimum illumination of 2 ft.-candles at 3 ft. above the floor it would be necessary to have lamps giving 200 c.p. at 30° below horizontal,

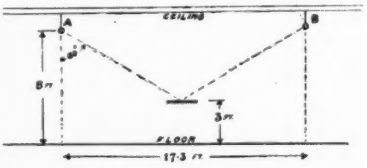


FIG. 1.—Lighting of corridors and passages.

whereas an ordinary corridor was of course lighted with 30 or 50 c.p. lamps, and sometimes only 8 or 16 c.p. A few actual values would still further emphasise the fact that 2 ft.-candles was far too high a minimum. He had been taking one or two readings in the new offices at Waterloo, where the corridors, which were quite comfortably lighted, gave a minimum of 0·1 ft.-candle and a maximum of 0·4 ft.-candle. The diversity here was very small and that probably accounted for the good lighting. In the corridor leading to the offices of the Illuminating Engineering Society, the minimum was 0·13 ft.-candle, and he thought everyone would agree that this was an excellently lighted place. The corridor outside the Institution of Gas Engineers gave a rather lower figures, being 0·075 ft.-candles, but that was due to the fact that alternate lamps had been removed owing to the present lighting restrictions. If it were assumed to be twice as much in normal times the figure would be 0·15 ft.-candle, still a very long way from 2 ft.-candles. In the Society of Arts building, on the stairs the minimum was 0·5 ft.-candle, but this was obviously exceptionally bright. The interesting point about all these tests was that they formed a striking vindication of the figure of 0·1 ft.-candle recommended by the Committee as a minimum for passage lighting. They must not forget that light of this character could easily be too extravagant, notwithstanding the argument (put forward by one of the witnesses) that as light was provided so cheaply there should be

plenty of it. Plenty of it, certainly, but not *too much*. An advocate of a certain system of lighting had once offered to give him five times the amount of light for the same amount of money as he was then paying, but he naturally retorted that he would rather have the amount of light he wanted for one-fifth of the price.

With regard to the lighting of open yards, he thought that the value of 0·05 erred on the side of being too high. In the case of a railway goods yard of about 14 acres, with the lighting of which he was concerned, the increase from the present actual minimum of 0·01 ft.-candle to 0·05 ft.-candle would involve an increase in expenditure for current alone from £300 to £1,500 per annum, assuming the existing installation was made use of. The increase would doubtless be less if the lamps were placed closer, but he estimated that under the best possible conditions the cost would be doubled in order to secure a minimum of 0·05 ft.-candle.

An editorial note in the *Journal of Gas Lighting* had ridiculed the figure recommended by the Committee, but in the hope of convincing the writer of this note that the Committee were well on the safe side he had, when recently visiting the offices of the Journal, taken a reading on the floor of the publishing department. He did not know whether this would be considered a "working area," a "passage," or an "open yard," but he could assure them that the illumination actually fell below the lowest minimum recommended by the Committee—it was in fact 0·035 ft.-candle. He need hardly say that this floor was not in the least dangerous to walk about on, nor was the lighting of the office as a whole in any way deficient. He merely mentioned this instance to show what a low degree of illumination we were accustomed to consider safe. Furthermore, he wished to emphasise that it was *minimum* illumination, *i.e.*, the darkest corner, that was specified, and this must not be confused with *average* illumination. Incidentally, if an instrument could be devised which would show the value of illumination in the same way as a thermometer indicated temperature it would be a valuable thing, and possibly the Society might award a gold medal to the inventor!

It had occurred to him that in view of the possibility of a minimum illumination becoming statutory, it might be of value to be able to predetermine the cost of lighting a yard with a given minimum. This could easily be done provided the average illumination which corresponded to the stated minimum could be arrived at. Then it would only be necessary to multiply the area of the yard by the average illumination to get the number of lumens required, and from the known efficiencies of various illuminants these lumens could be converted into actual cost. The difficulty was to arrive at the average illumination, but he thought the following method would give a reasonable approximation. A knowledge of the diversity ratio for a given system of lighting would enable the maximum to be deduced at once from the minimum. This diversity ratio would depend on the spacing of lamps, and could in most cases be estimated pretty accurately. It was clear that the average illumination would not lie half-way between the maximum and the minimum, because of the rapid falling off in the distribution of light from a source. He showed two typical horizontal distribution curves (Fig. 2) in which he had

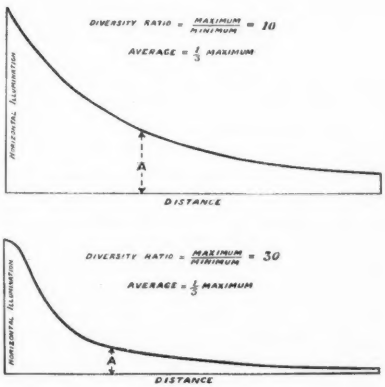


FIG. 2.

calculated the average by dividing the area of the curve by its base. In one case the average was one-third of the maximum, and in the other case, where the falling-off was more rapid, the average was only one-fifth of the maximum. In this way, by plotting the horizontal distribution

curve of the particular lamp between the maximum and minimum values as given by the diversity ratio, it was possible to get at a working average illumination, and thus to predetermine the cost.

He would like finally to refer to the question of accidents on railways. He had had access to the Board of Trade returns, and had thought it would be interesting to analyse them out and plot them in diagram form (Fig. 3). He had

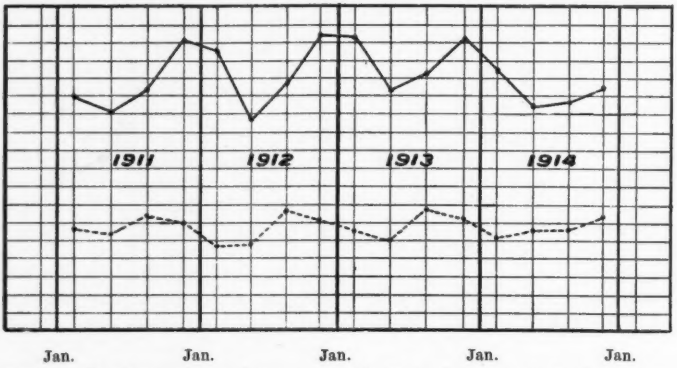


FIG. 3.—Showing relation between accidents and the period of year on railways (taken from Board of Trade Returns). Upper curve refers to railway servants, lower curve to passengers. (Accidents on the permanent way and in trains and rolling stock are omitted as being unaffected by lighting conditions.)

taken the accidents which were more or less dependent upon illumination, *i.e.*, he had eliminated accidents occurring to trains, permanent way, or rolling stock. The upper curve showed the accidents to railway servants and the lower curve those happening to passengers. In the case of railway servants, the figures showed that these were very much more general in the winter quarters than in the summer. The somewhat smaller increase in the fourth quarter of 1914 might presumably be due to the fact of the reduction in the number of railway employees by enlistment; but taking the figures over a period of years, it seemed that there were 18 per cent. more accidents during the winter than the summer. After making due allowance for fogs, &c., he thought it could be safely deduced that the greater frequency of accidents in the winter was mainly due to the dark days. In the case of passengers an increase in the third quarter of the year was explained by the fact that it included the holiday traffic.

He did not know if it was generally realised that at a Board of Trade Inquiry into an accident, some of the first questions usually asked were in reference to the lighting—whether the lights were all on, were they in good condition, when were they last cleaned, and so on. It was clear that the Board of Trade Inspectors regarded adequate illumination as an extremely important matter.

Mr. C. C. PATERSON, having congratulated the opener of the discussion, expressed his interest in Mr. Cunnington's accident curves, which, if anything, underemphasised the effect studied as to the extent to which accidents occurred during the winter months. Winter months, of course, contain a lot of daylight as well as artificial light, and the daylight accidents would be presumably the same as the daylight accidents in the summer months, so that an increase of accidents in the winter months was purely the result of additional accidents during the few additional dark hours in winter over the number in summer. If we were to try to work out these curves on the basis of the actual hourly rate at which the accidents occurred during the hours of evening as compared

with the hours of daylight, the curves would be still more exaggerated. This was a point to be taken into consideration in connection with comparisons between accidents in the winter and summer.

He would recommend those who desired to judge of the general condition of lighting in this country, to study the volume of the report which was about to be issued and which contained much statistical and other information and detailed plans of factory premises.

Mr. JUSTUS ECK said it was not often that a branch of engineering was so thoroughly taken up and dealt with by the Government as had been done in this case, and he hoped that it would not be long before the third volume of the report of the Committee appeared. If there was any prospect of this being delayed, perhaps some means could be taken to publish an interim report covering the scope of the new volume. The urgency of the matter was very great at the present time, as so many of our factories were working all hours of the day and night, and which brought them within the category of the railways, in which there was no cessation of work during the whole of the 24 hours.

One of the most important things to consider in factory lighting was the effect upon the eyesight, and in this connection it was very sad to see the large number of people who wore spectacles, the use of which in many cases from his own observation was a considerable hindrance to the working facilities of the man. Anything which could be done to render the necessity for spectacles less, would be a service not only to this country but to the whole world. The general tendency was to continue to hurry on improvements in our producing methods and to overlook the effect of good lighting upon the eyesight of the workman who would work on these improvements in producing methods, often causing an expense in other directions.

He would also like to see some method devised for compelling greater attention to reports such as this. Recently he had had to visit a number of small factories, and had been surprised at the almost universally bad lighting systems. At a small works in Canning Town on the previous day where it had been necessary to put up blinds to comply with the present lighting restrictions, dark green blinds had been used, and the result was worse, internally, than before. He immediately suggested the very simple remedy of pinning a few newspapers over these blinds, and putting a little whitewash on the walls, with the result that he was certain the factory output had been increased by five, if not ten, per cent., and there was certainly greater safety. In another factory, he had all the blinds faced inside with white material, and the output was better than ever before. To emphasise this point, he might mention that he had visited a good many factories in the United States, and although the Illuminating Engineering Society of America had been longer at work than our Society in this country, it did not seem to have brought home to manufacturers so clearly as we had, the necessity for better lighting in factories. He had been deeply disappointed with factory lighting in general in America. Another point which the Committee might take into consideration in its further work was the question of the colour of light. He had had to advise in connection with the lighting of some works where small objects were being produced in large quantities in brass, and there had been great difficulty in the supervision and inspection of these owing to the colour of the artificial light.

Mr. LEWIS SOLOMON, speaking from the architect's standpoint, said that he preferred to work by rule of thumb. In designing a factory, he asked the manufacturer where he wanted the light and followed his instructions both as to artificial lighting, and natural light in the matter of windows. It had occurred to him, however, that if factory inspectors could be instructed to report to some authority the superficial and cubical amount of light, whether vertical, horizontal, or at an angle in each factory they visited during the year, *and to report also whether the result was good or bad* (this information being obtained from the manager of the works) a considerable amount of valuable data would be accumulated.

Mr. E. F. SWINSON agreed with Dr. Kerr in attaching considerable importance to the question of fatigue from bad lighting and in this connection also matters relating to ventilation and heating must come under consideration. It was easy to put down a certain indicated result as being due to a particular cause, but in practically every instance there would be conjunctive factors present, and to give predominance to lighting was to leave out of consideration important questions relating to fatigue, ventilation, and heating.

Mr. G. CAMPBELL said he was sorry to have to strike a note of discontent with the Report, because he fully appreciated the immense amount of labour involved in compiling such a record. In spite, however, of Mr. Gaster's able defence of the Report, he was still of the opinion that apart from its collection of miscellaneous information it must, from the point of view of its recommendations on the numerical values for suggested standards of illumination, be regarded as a disappointment. Irrespective of the explanation, anyone who had any practical experience must know that an illumination of 0·25 ft.-candle for factory lighting was totally inadequate for 99 per cent. of examples.

He presumed that the intention of the Committee was to obtain legislation that would compel all factory proprietors to adopt necessary lighting.

In his opinion the Committee had missed a great opportunity in not coming out with a flat declaration that the minimum result for good illumination in workshops is generally 1 to 3 ft-.candles, and that otherwise the lighting of factories would be bad.

Added (*communicated*): It is hardly necessary for me to add that my remarks as to foot-candle values applies to workshop-interior lighting and not to exterior lighting, where special circumstances other than foot-candle values must be considered, with regard to which anyone interested can refer to the discussion on and the Report of the Society's Street Lighting Committee.

Since the meeting my attention has been drawn to the point that the value of 0·25 ft.-candle is intended as a practical *legal minimum* in the interests of *safety* only, and is quite apart from the much higher illumination necessary for the carrying on of work which would come in the Report under the heading of "adequate and suitable lighting." For such purposes, I hope, standards will be eventually prescribed by the Committee. These values would necessarily be much higher. In the meantime the 0·25 ft.-candle minimum recommendation must not be confused with satisfactory workshop-interior illumination.

It is in the sense, then, of indefinite recommendations as regards "adequate and suitable lighting" that I consider the Committee's Report disappointing, but in no way wish to detract from the value of such Report from the standpoint of the progress of the Illuminating Engineering movement.

Mr. F. W. GOODENOUGH differed from the last speaker in regarding the report as "a disappointment." On the contrary, he regarded it as a very great achievement to have established the principle that adequate and suitable lighting for factories and workshops should be a statutory requirement. It was very necessary in these matters to build sound foundations before putting up a big super-structure, and the Committee had done wisely in making a small beginning with regard to the minimum. At the same time they had made a very large beginning in establishing the principle that the good lighting of a factory was one of the conditions which enabled it to be passed as satisfactory by the Home Office inspector. It was a very important principle in legislation not to go too far in advance of public opinion; otherwise there was a risk of the legislation being brought into contempt and thrown into disuse. It was the work of the Society to advance public opinion in this question of satisfactory illumination, as to the minimum, maximum and average illumination, and if public opinion was educated in this respect, it would be easy to get legislation to follow. Legislation must always be subsequent to the education of the public, or it would fail of its object. The great problem of the nation not only at present, but in the years to

come, was how to increase the output of wealth in this country (*i.e.*, the output of labour) in order to provide the means to pay for the war, and if by the adoption of statutory requirements as to the lighting of factories, we could bring about a natural increase in the output per man, we should have done a service to our day and generation. In that respect he maintained that the report was a very valuable step in advance. With regard to Mr. Cunnington's remark as to the man who advocated a high degree of illumination because it could be obtained cheaply, personally he was not interested for the moment in what the illuminants might be, but Mr. Cunnington must bear in mind that it was only by th advent of cheap illuminants that we had been able to get the standard of lighting raised to anything like the present figure. It was the line of argument that the metallic filament lamp maker used against the carbon filament lamp maker, namely that he was able to give a better light because it was cheaper. Progress should be utilised partly in getting a better result, and partly in getting economy, and if we had not got beyond the tallow candle at the present day, it would not be possible to prescribe standards of illumination for factories. He thought that Mr. Cunnington would recognise that the witness who advocated 2 ft.-candles for passages was merely emphasising the real truth that before thorough efficiency was obtained there must be economy.

H. C. WHEAT (*communicated*) :—Just as everyone connected with the lighting industry welcome the appointment of a Committee to inquire into Industrial Illumination, which was no doubt intensified when the names of the gentlemen forming the Committee were published, so the issue of the first report of the Committee, with its extensive appendices, should bring conviction to others of the importance of the subject, and its enormous extent. The due appreciation of all the work and time that the first report represents, must, to a large extent, be limited to those whose daily work renders them familiar, at any rate to some extent, with the different aspects of the subject. As one of the latter I should like to record myself.

From the various comments that have already appeared, it is evident that the Committee had no small task before them if they were to make definite proposals for all the different conditions which seem to be considered within their scope. One can well understand that in making recommendations for legislation it is easy to be carried away by an ideal, and to forget the hardships, and perhaps injustice, which such a proposal would enforce on those required to carry it into effect. This doubtless explains why the minimum values suggested appear so low to many of us who are accustomed to frequently make recommendations for similar cases on a much higher scale.

In eventually deciding on the conditions of illumination necessary for various classes of work, it might be well to consider the distinctions implied by :—

(1) General illumination ;
(2) Localised general illumination ;
(3) Local lighting.

In such cases the minimum values would naturally be specified on the " working plane " rather than floor level.

One may also hope to see in course of time more detailed recommendation on the screening or shading of light sources, seeing the number of offences against this which are committed. Almost any works will afford an example of this, and also of the fact that protection is desired, judging by the number of lamps that are furnished with scraps of paper, or other amateur efforts at shading.

The appendix may appear antagonistic to inverted lighting, but should not be construed as applying to general conditions. In these experiments the majority of the tests recorded are made on self-colour fabrics, &c., where unidirectional light is most necessary for clear vision, and for which, therefore, indirect lighting is naturally unsuited ; in fact, no unbiased person would suggest it for such duty. There are, however, admittedly other classes of work where the diffusion and other excellent properties of indirect lighting render it far superior, and the efficiency of the eye remains higher under this than in any other system of artificial lighting. No one could expect that a sudden change from direct to indirect lighting would favourably impress any

ordinary person. It is fairly well established that people largely estimate the value of light by what they can *see* of the light source, and even with direct lighting people *fancy* that there is more light when the source is exposed rather than when screened.

In conclusion, I am sure that we all are very much indebted to the Committee for the work they have done, and for a great deal of valuable information which they have given us.

The CHAIRMAN, before calling upon Mr. Gaster to reply, said the discussion had placed a considerable amount of information at the disposal of the Committee, and a good indication had been given as to the way the report was looked upon, and what were the points the members of the Society desired further investigated. To all of these the Committee would turn its attention when it was able to resume its work. The question raised by Dr. Kerr and Mr. Swinson with regard to the questions of fatigue and glare were clearly of the very utmost importance.

Mr. LEON GASTER (*in reply*): In the course of my introductory remarks I expressed appreciation of the sympathetic way in which the Report has been received in the press, and would like to express now my pleasure in listening to the cordial remarks of the various speakers in the discussion. It is gratifying to feel that the great importance of the Report, as a step forward towards better industrial lighting, is fully recognised by members. No doubt this beginning will be followed up by other useful work.

It was a great pleasure to see present Dr. Rene Sand, whose acquaintance I made at the important Brussels Congress, and to have his assurance that when happier times arrive, the question of industrial illumination will receive the attention of authorities in Belgium.

Dr. Kerr's remarks on the effect of poor illumination in causing industrial fatigue were most welcome. The case he mentions of the increased sensitiveness to glare caused by tobacco amblyopia illustrates one point mentioned in the introduction, namely, the close relation between defects of vision and the illumination required for work. Inadequate illumination, it is generally agreed, imposes a strain on the eyes; similarly defects in vision, whether due to some physical disturbance or to general bodily fatigue, will often make a worker sensitive to defects in lighting which might otherwise pass unnoticed.

Mr. W. R. Cooper, while referring to the Report in sympathetic terms, made one or two suggestions, for example, that 0·25 foot-candles appeared somewhat low as a minimum. The reasons for selecting this value were somewhat fully summarised in the introduction, but I may add that one other reason for not making the value desirable in the interests of safety and convenience too high is that in this way the obvious need for a much higher value for the work is made evident. Had a higher value, say one foot-candle, been demanded there would naturally have been some confusion between this and the illumination necessary for carrying out processes, and there might have been a tendency to assume that the legal minimum was all that was needed. By adopting 0·25 foot-candles we ask for a value which is clearly justifiable, does not impose hardship, and yet makes it clear to the factory owner that additional illumination for the work must also be provided; or, on the other hand, if there is local lighting on the work the illumination of the rest of the area must reach the minimum desirable in the interests of safety.

Mr. Cooper also suggested that some attempt should be made to discriminate between different classes of workshops. All must agree that the requirements of workshops differ very much according to the nature of the work, and naturally this point would be sympathetically considered by inspectors of factories. On the other hand, when one comes to attempt a classification, one finds oneself in great complexities, and it therefore seems better to start with simple recommendations which can be applied to all. No doubt when one comes to consider the requirements for different classes of work some broad lines of classification will have to be considered.

Mr. Cunnington's very able contribution to the discussion fully confirmed, by actual observations in well-lighted passages, the view that a minimum

of 0·1 foot-candles is ample in such cases; and that in respect to the lighting of large yards and sheds, 0·05 foot-candles could not be considered unduly low. Indeed, it is interesting to observe that in his experience it might, in some cases, be difficult to secure even this value with a reasonable expenditure. Hence the need for the exemption clause. Mr. Cunnington's figures for accidents on railways are also most interesting and show how careful one must be in interpreting statistics of this nature.

Mr. Eck expressed the hope that the Report would receive widespread attention. It should be the work of this Society to ensure that its contents are made known to all interested in lighting, particularly engineers concerned with lighting schemes. Illuminating engineers should study the Report in detail, and I venture to think that the Memorandum accompanying it will help considerably towards making its main points clear. Mr. Eck's instance of the effect of good illumination in increasing output was welcome, and we should like to get all the information we can of this kind. The question of the colour of the light is, as he says, a most important one in certain trades; this, however, will no doubt be a subject for the Committee to consider at a later stage.

I quite agree with Mr. Swinson that ventilation and heating is a most important matter and must often be considered in conjunction with the lighting, especially in daylight work.

With reference to the point raised by Mr. Campbell, I am glad to note that since the meeting he has recognised that the 0·25 foot-candles is to be provided *without prejudice to* the illumination necessary for carrying on work. Naturally, in those cases where the factory owner provides a high general illumination all over the shop, there will be no difficulty in keeping above the prescribed minimum value, but it is also necessary to ensure that in those cases where local lighting over the work is used, the illumination in the intermediate regions will be sufficient for safety. As mentioned in my remarks on Mr. Cooper's contribution, the mere fact of this "safety-illumination" being comparatively low, and obviously insufficient for carrying out any but the roughest work, is the best safeguard against any confusion of the kind Mr. Campbell fears. If, however, one were to ask for *one* (or still more, *three*) foot-candles everywhere, there would be a risk of such confusion. For many processes even this illumination would not be enough, while in others it would constitute undue hardship. Mr. Campbell will find that Vol. III. of the Report will afford much information as to the actual conditions of illumination which prevail in factories at the present time.

Mr. Goodenough, out of his large experience, has expressed his appreciation of the Report and his recognition of the need for cautious procedure in dealing with novel problems in legislation such as this. The mere fact of such a Report being issued is surely a great vindication of the value of the illuminating engineering movement. Needless to say, we must also all agree with Mr. Goodenough that advances in illuminants, by cheapening light, have had a great and beneficial effect on illumination. As a Society we should certainly impress on the public the foolishness of parsimony in this respect.

Since the discussion a communication has been received from Mr. Wheat, who gave most useful evidence before the Commission. Mr. Wheat emphasises the need for good shading appliances, a point that was also raised by Mr. Cooper.

I think that it will be agreed that this point has been most strongly emphasised in the Report and it forms one of the four requirements under the general head of "adequate and suitable lighting," namely :—

(1) Adequacy.

(2) A reasonable degree of constancy and uniformity of illumination over the necessary area of work.

(3) The placing or shading of lamps so that the light from them does not fall directly on the eyes of an operator when engaged on his work, or when looking horizontally across the workroom.

(4) The placing of lights so as to avoid the casting of extraneous shadows on the work.

I quite agree with Mr. Wheat that the few tests on indirect lighting should not be interpreted as a general condemnation of this system, and only apply to the particular processes specified (embossed materials, engraving on metal, &c.), which appear to require special directional lighting. In the Report itself it is definitely stated that no differentiation has yet been made between direct and indirect lighting, and the experiments on this point were incomplete when war broke out. Nevertheless, it seemed desirable to include these experiments among the others in this section of the Appendix.

In conclusion, I would like to express the opinion that the claims of good illumination are so clear that I am confident that they will be accepted by manufacturers with very little persuasion; any attempt to impose unduly severe requirements before they are fully understood or appreciated would in the long run be prejudicial to the cause of good lighting, and this is fully recognised in the moderate tone of the Report.

I should, however, like to say that I quite sympathise with the views of those who would like to see some more detailed treatment of problems in industrial lighting, in order to supplement the general official recommendations in the Report, and I hope that our Society will deal with these matters in future meetings. Finally, I must express my very great appreciation of the kindness of Dr. Glazebrook for presiding to-night in spite of the many calls on his time at the present moment.

NEW MEMBERS OF THE SOCIETY.

THE names of applicants for membership read out at the previous meeting on May 18th were formally announced at the last meeting on November 23rd, and these gentlemen were formally declared members of the Society.

In addition the names of the following gentlemen have been duly submitted to the Council and were read by the Hon. Secretary at the last meeting:—

Brown, Douglas Elyard	Electrical Engineer to Messrs. C. A. Vandervell & Co., Hillbank, Abbots Langley, HERTS.
Butts, E. W.	Messrs. Siemens Bros. Dynamo Works, Ltd., Upper Thames Street, E.C.
Ellis, F.	Manager of Messrs. Johnson & Jorgensen, Ltd., Glass Suppliers, Farringdon Street, LONDON, E.C.
Grigsby, O. E.	Electrical Engineer, The Benjamin Electric Co., Rosebery Avenue, E.C.
Pallot, A. C.	Lieut., Royal Engineers (T.F.), St. Heliers, Sheffield Road, PORTSMOUTH.
Wells, C. F.	Dundee Corporation Electricity Works, DUNDEE.
Wood, W. H.	Manager, Commercial Acetylene Co., 712, Dufferin Street, TORONTO.

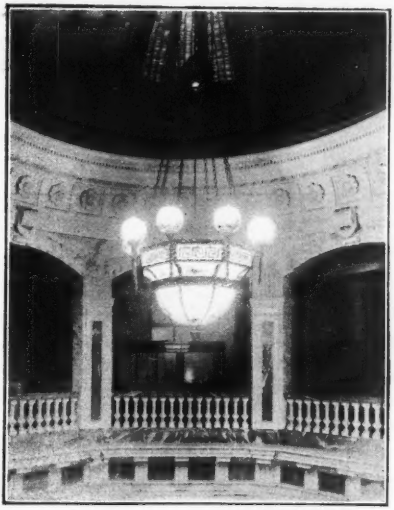
AN EXAMPLE OF MODERN OFFICE LIGHTING.

OFFICE lighting, broadly speaking, includes a great variety of installations. The needs of a small office where there are only a few desks and typewriters to be lighted are essentially different from those of large banks, insurance offices, &c. In the latter case there are often a large number of people at work in a single room, and there are other considerations besides the purely utilitarian one for providing enough light for the work to be done. In buildings of this class an imposing interior, in keeping with the important character of the business transacted, is necessary. People entering a building of architectural distinction are favourably impressed by the substantial character of the firm, whereas they would be inclined to think less of a concern with badly arranged and poorly lighted offices.

In such cases, therefore, the lighting scheme should be dignified and imposing, in keeping with the character of the interior, and the decorative element comes into play. The lamps and fittings must not only accomplish their primary purpose of providing light at the desks and counters, but should "set off" the interior to the best advantage and enable its architectural features to be appreciated.

A good instance of modern office lighting is furnished by the new office of the Phœnix Assurance Company, Limited, in King William Street, London, E.C. This building, which is one of the finest in London, is from designs in the Classical Renaissance style by the late Mr. J. Macvicar Anderson and Mr. H. L. Anderson. The entire block covers an area of 12,000 square feet, and is eight storeys in height, thus affording ample scope for ingenuity and good taste in the matter of lighting. By the courtesy of the Consulting Engineer, Mr. S. G. Castle Russell, we were recently afforded an opportunity of taking a few photographs and measurements of the illumination in this building. The illustrations give a fair idea of the general design, although the proportions are rather too big to be conveniently shown in a photograph. Readers will, no doubt, be struck by the rather singular grey columns. We understand that these columns will eventually be light marble—but the material is held up during the German occupation of Mons.

This is probably one of the largest semi-direct lighting installations in London, there being about 1,200 lamps of 20 to 100 watts each. The ground floor office occupies approximately 65 square feet and is lighted by 22—100 watt "half watt" lamps in diffusing glass reflectors, hung at a height of 14 feet. (See Figs. 2 and 3.) In addition to these lights there is a large central chandelier (shown in Fig. 1).



Lumina Bureau Photo.

FIG. 1.—Centre Chandelier.

This was specially designed to suit the decorative requirements of the office, besides assisting the illumination on the ground floor. Measurements show that the illumination of the counters is of the order of 3 to 4 foot-candles, the corresponding values on the desks under the galleries being 4—6 candles. The whole of the fittings are of handsome Georgian style and were specially designed for the building.

Lumina Bureau Photo.

Lumina Bureau Photo.

FIGS. 2 & 3.—Views of the ground floor of the Phœnix Assurance Co. (King William Street, E.C.), illuminated by "Half-watt" lamps in diffusing glass bowls.

There has been, during recent years, a great deal of discussion as to whether general lighting of this kind is advisable in banks or offices, or whether local lamps for each worker are needed. The latter system, once universal, is being gradually replaced and there seems good ground for thinking that general illumination will do all that is necessary, providing the illumination is well distributed, and the filaments of lamps are screened by suitable globes or hemispheres. In the earlier installations of this class, before the more efficient incandescent lamps were introduced, preference for local lighting was, perhaps, due to the fact that the working illumination was not always sufficient for ledger work. In the present instance, however, the illumination provided seems ample.

ACCIDENTS DUE TO DIMINISHED STREET LIGHTING.

ANOTHER instance of a fatal accident ascribed to the diminished public lighting is described in the *Evening News* as follows:—

The peril of reduced street lighting owing to the war was emphasised at an inquest at East Ham to-day on Richard Matteson, of Green Street, Upton Park.

He rode out of Green Street on a cycle into the Romford Road, Forest Gate, and collided with a taxicab. He was killed on the spot. The scene of the accident was described as one of the most dangerous in the district.

The jury, in returning a verdict of accidental death, said it was due mainly to the reduced lighting. They exonerated the driver of the taxicab from blame. They regarded Matteson to a certain extent as a war victim.

The coroner said the man had been sacrificed to the needs of the war in the same way as others had been sacrificed at the front.

HOODED LAMPS FOR STAIRCASE LIGHTING.

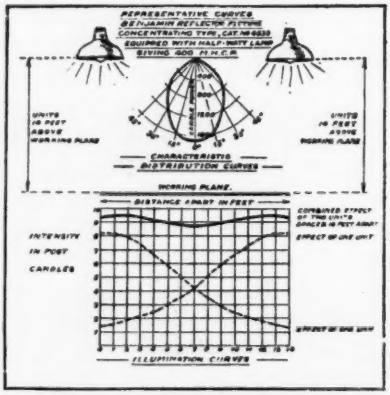
THE lighting of stairways is one of those simple problems which are often incompletely solved, merely because they do not receive enough attention. One not infrequently sees unnecessarily powerful lamps used for the purpose, and their utility is much restricted by lack of proper screening appliances. As a matter of fact, quite small miniature units often suffice for the purpose, provided the lamp is completely screened from persons using the stairs (especially those *descending*), and the illumination is distributed evenly along the flight of stairs. In the case of buildings used mainly by old and infirm people, who are particularly liable to trip, and cannot recover themselves easily if they do so, and in buildings constantly used for meetings of various kinds, good stair-lighting is particularly important. It should be made a special feature in hospitals, infirmaries, homes for incurables, &c.

An instance was afforded at a recent meeting attended by veterans of the American Civil War in a Chicago armoury. Through the thoughtfulness of those responsible for the gathering, a special hooded lamp was employed at the foot of a long flight of stairs, so that all the old soldiers reached the last step in safety.

BENJAMIN "HALF-WATT" ACCESSORIES.

We are familiar with the data available on the spacing of reflectors of the E, I, and F type for ordinary tungsten lamps, and it is satisfactory to note that the range of fittings of this type available for half-watt lamps is rapidly growing.

The Benjamin Electric Ltd. have issued a useful pamphlet (List No. 506) in which a great variety of half-watt fittings are described. Some of these are of the usual steel type, others are enamelled, and there are also cluster fittings. In each case the polar curve and the appropriate spacing rule for even illumination are given together with an illustration of the fitting, the whole being assembled conveniently on the same page. We reproduce a typical reflector and polar curve. Special holders have been designed to avoid excessive heating and some of the types are specially prepared with a view to being weatherproof.


REPRESENTATIVE CURVES
BENJAMIN REFLECTION FITTING
CONCENTRATING TYPE, CAT. NO. 0530
EQUIPPED WITH HALF-WATT LAMP
GIVING 200 M.C.P.
UNITS IN FEET ABOVE WORKING PLANE
UNITS IN FEET ABOVE WORKING PLANE
CHARACTERISTIC DISTRIBUTION CURVES
WORKING PLANE.
DISTANCE APART IN FEET
INTENSITY IN POST CANDLES
COMBINED EFFECT OF TWO UNITS SPACED 14 FEET APART
EFFECT OF ONE UNIT
ILLUMINATION CURVES

Characteristic photometric curve.

Half-watt Reflector Fitting (concentrating type, detachable flange pattern), for interior or exterior use with "One-watt" lamps up to 400 watts and "Half-watt" lamps up to 200 watts.

It is interesting to note that semi-indirect fittings are listed for "half-watt" lamps up to 1000 watts, and there are also angle-type reflectors for special lighting.

The booklet commences with some general notes on industrial lighting, definition of the chief units, and desirable values of illumination for various classes of work being quoted. An example is given of how the consumption necessary to produce a given illumination may be readily calculated. Finally there is a page devoted to Marbella reflectors, and a summary of miscellaneous accessories such as Goliath screw lampholders, brackets, ceiling plates, &c.

There is no doubt that the assembling of information of this kind is a great help in planning the lighting of factories, and by using well-known types of E, I, or F type fittings, for which the polar curves are known, the resulting illumination can now be determined beforehand with quite sufficient accuracy for practical purposes.

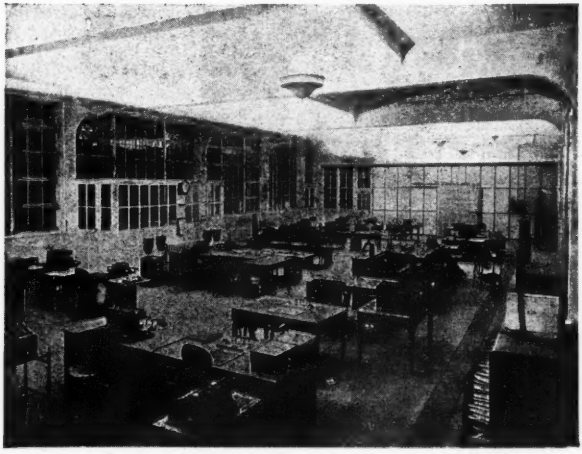
If we might make a suggestion for a future edition, we should like to see similar data provided for the semi-indirect fittings. No doubt in this case the illumination could not be predicted quite so readily owing to the important influence of reflection of light from the surroundings. But the approximate best spacing could be determined experimentally and, from experience of actual installations, the order of illumination for a given consumption of energy per square foot could be roughly indicated.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

INDIRECT OFFICE LIGHTING.



Typists' room in the offices of the Chiswick Polish Company, Limited, lighted by means of Mazda lamps in "Eye-rest" indirect lighting fittings.

THE accompanying illustration shows a good example of modern indirect office lighting, namely, the typists' rooms of the Chiswick Polish Co. The side of the office in the background is almost entirely of glass, the windows being carried up as high as possible so as to take full advantage of high-angle light. In the matter of artificial lighting arrangements have also been made to gain good diffusion of light. The room is illuminated by a number of moulded compo. "Eye-Rest" fittings, each containing five Mazda lamps, in an appropriate X-ray reflector.

For this illustration we are indebted to the British Thomson-Houston Co., Ltd. The lighting of desks occupied by typewriting machines is an interesting one. It is well known that when local lights are employed their position has to be adjusted with some care, and is apt to be upset by any alteration in the grouping of machines. In such cases there is therefore much to be said for a well-diffused general illumination, avoiding inconvenient shadows however the machines are situated.

REVIEW OF BOOK.

Physical Optics. By Professor R. W. Wood. (Macmillan & Co., London and New York, 1914; 705 pp., 399 illustrations.)

PROF. WOOD'S comprehensive volume carries the student a considerable distance further than do most treatises on Optics, and contains some of the very latest work on this subject.

The earlier chapters on The Nature of Light; its Propagation, Reflection and Refraction, follow more or less conventional lines, but are decidedly fuller and more advanced than is the case in most text-books, and contain some novel diagrams and methods of treatment. Interference, Diffraction, Polarised Light and Spectroscopy are treated in a quite up-to-date manner, while the concluding chapters break what will to most students be new ground. The discussion of Radiation is particularly interesting, although we personally would have liked to have seen a somewhat fuller account of the bearing of this subject on artificial light production. We notice a plate of one of Prof. Wood's celebrated landscape photographs by infra-red rays. Of considerable interest is the chapter on the transformation of absorbed radiation, which is also illustrated by special plates, and the discussion of the scattering effect of fine particles and the theory of "optical resonance," which is also a field of study Prof. Wood has made his own.

The chapter on magneto-optics contains a considerable amount of matter not readily found elsewhere, and we note that the author has been fortunate in receiving particulars of some of the very latest researches of Prof. Zeeman. In the preface to this new edition Prof. Wood suggests that some readers may consider that an unduly large space has been allotted to lines of experiment with which he has been intimately associated. We think that, on the contrary, the references to this special work render the book of special value and give it a distinctive character. We have already a number of excellent works on the fundamental principles of Optics to which Prof. Wood's book will form a useful supplement.

PERSONAL.

WE note that Mr. Malcolm Macfarlane, a member of the Illuminating Engineering Society, has now been granted a Commission in the Royal Engineers (1st London Division).

A NATIONAL GAS-LIGHTING WEEK IN THE UNITED STATES.

WE notice that an apparently very successful "gas-lighting" week was recently organised in the United States, displays being arranged in many cities. For example, the display at Jersey City included many tasteful model shop-window lighting exhibits, a feature being the number of semi-indirect lighting units. The attendance during the first week exceeded 4,000, and almost all the appliances exhibited were sold. As an educational campaign the display was also a marked success, visitors coming from most of the gas companies in the district and also from the Master Plumbers' Association of Hudson County.

A striking exhibit at Wilmington (Del.) was a window containing a complete model of a section of the proposed Du Pont Boulevard, the houses being shown to scale and miniature mantles on small posts and even small model motor-cars being shown. We observe also a series of excellent photographs showing the exhibits at Newark, some of the model interiors fully equipped with suitable "Christmas gifts," being particularly attractive.

A feature of the campaign was the prominent advertising of the National Gas-Lighting Week in the local papers.

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This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

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THE INDUSTRIES OF THE EMPIRE FAIR.

We have received a prospectus of the coming Industries of Empire Fair, to take place in the Palace of Industry, Willesden Green, during March 6th-25th, 1917. It is to be hoped that the War will have terminated at least by that date, and if so the moment will be very opportune to encourage British trade. It is stated that the building in which the fair is to be held will occupy more than three times the space filled by any other exhibition building in London, and will thus be one of the largest of its kind in the world. As previously mentioned there is to be a special Heating, Lighting and Cooking Section at which we hope full justice will be done to illumination.

Those interested should communicate with the Administration Offices, Lincoln House, High Holborn, W.C.

"WHO'S TO BLAME?"

Under this title **Holophane Ltd.** issue an attractive little notice laying stress on the need for good industrial illumination and drawing attention to the flicker and inconvenient striations caused by lamps enclosed in wire guards and tin shades instead of properly designed reflectors. "Scientific Lighting," it is claimed, "is cheaper than "Rule of Thumb Lighting." A man cannot turn out first-class work with poor tools; neither can he do so with badly directed light. In the Holophane System of Industrial Lighting the light is properly distributed and such defects as the above are avoided.

The front page of the leaflet shows a picture of the employer and the workman discussing the matter.

"LIGHT AND MUNITION WORK."

A circular from the **General Electric Co., Ltd.,** likewise emphasises the value of properly designed reflectors to aid good lighting, and quotes the definition of adequate lighting contained in the recent Home Office Report. Evidence is quoted to the effect that imperfect lighting conditions diminish the output and give rise to accidents, and reference is again made to the superiority of scientific methods to procedure according to "Rule of Thumb."

RECOVERY OF MANTLE ASH.

We notice in a recent issue of the *Journal of Gaslighting* an account of experiments of Herr J. van Rossum du Chattel, Director of the Amsterdam Gas Works, on the recovery of rare earth materials from spoiled or used mantles.

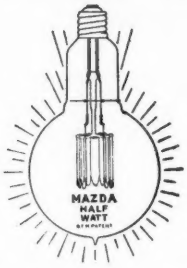
In Amsterdam boxes are provided (each holding 25 kilos.) for the collection of used mantles by workmen engaged in the attending to burners. It is stated that from 1000 used mantles enough material is obtained for the impregnation of 270 new ones. It may, however, be necessary to add a certain amount of cerium nitrate to the solution thus obtained before it is fit for use.

BRITISH-MADE MANTLES.

The same issue of the *Journal of Gaslighting* contains a letter from Mr. F. D. Marshall on imported mantles. Mr. Marshall gives an account of a visit to the Deutsche Gasglühlicht Aktiengesellschaft before the war, in the course of which he was shown a number of German factories. It is common knowledge that in those days this country was dependent to a very great extent on material and even apparatus imported from Germany, and it is to be hoped that a different state of things will prevail after the war is over.

It is evident, however, that an industry of this kind cannot be built up without much patience and energy. No one can help recognising the immense labour and energy which has been bestowed on this problem on the Continent; yet if we in this country bring similar efforts to bear there is no reason to fear that we cannot do as well. Happily in many directions considerable progress has already been made since the outbreak of war.

MUNITION FACTORIES AND WORKS ALL OVER THE COUNTRY ARE USING MAZDA LAMPS.



Good lighting was never more important than now. All over the country huge factories are engaged without ceasing on war work. There is no night for them, thanks to artificial light. Mazda Lamps are turning night into day in hundreds of factories—shedding their light so that many thousands of workers may perform their urgent work expeditiously and well. Instal Mazda Lamps without delay and gain the benefits of increased production, greater accuracy, and reduced costs.

We shall be pleased to give the fullest assistance in regard to industrial lighting.

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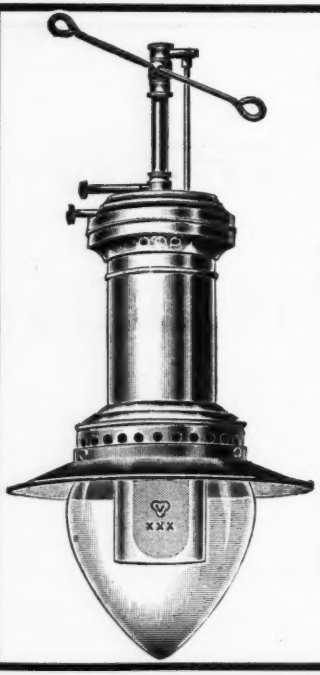

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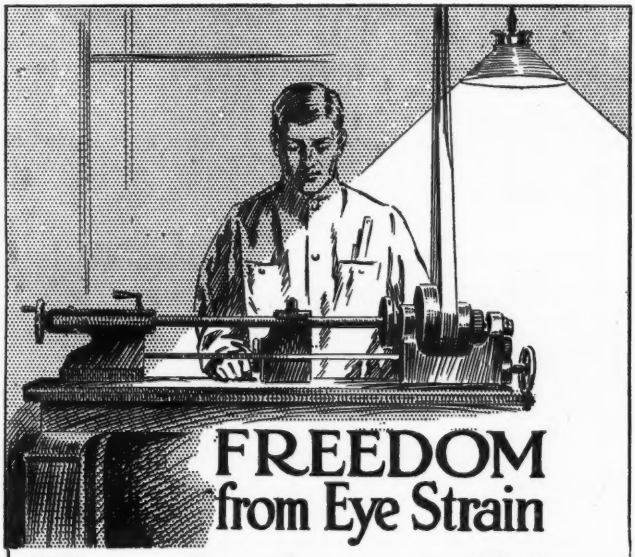

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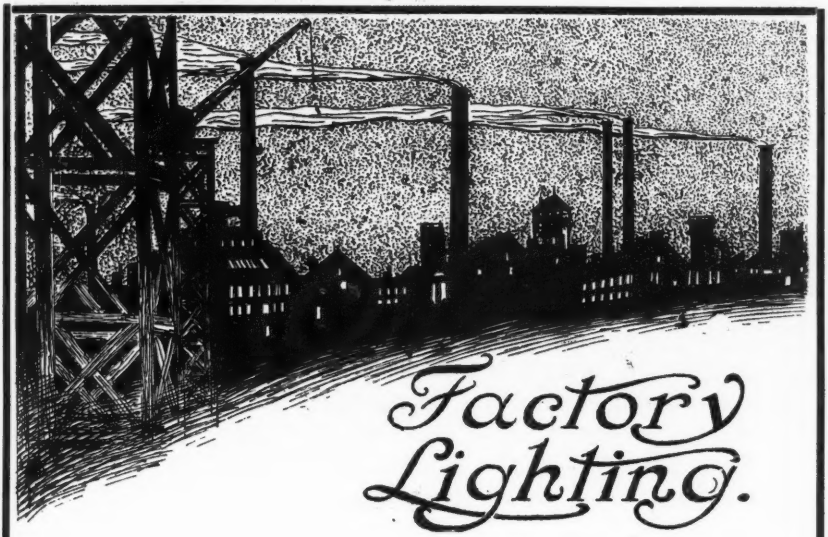

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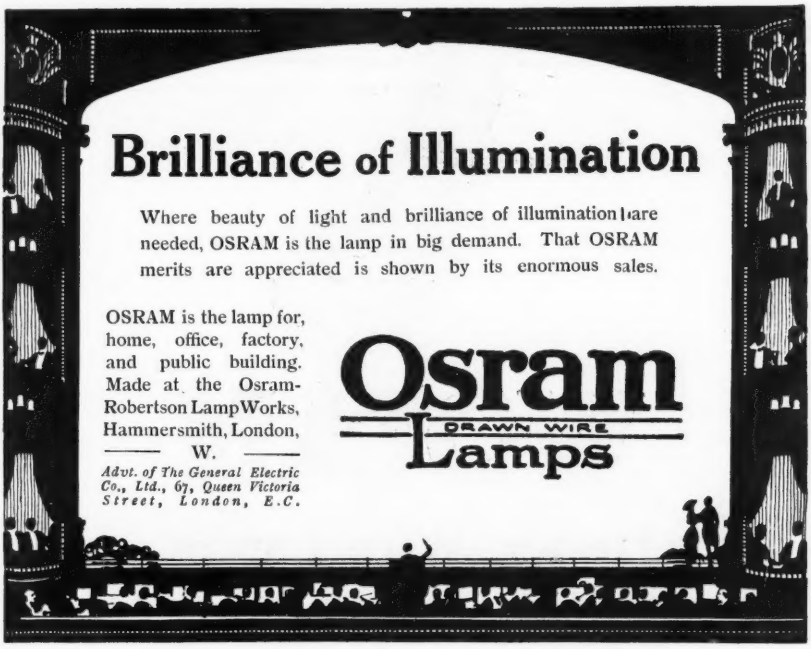
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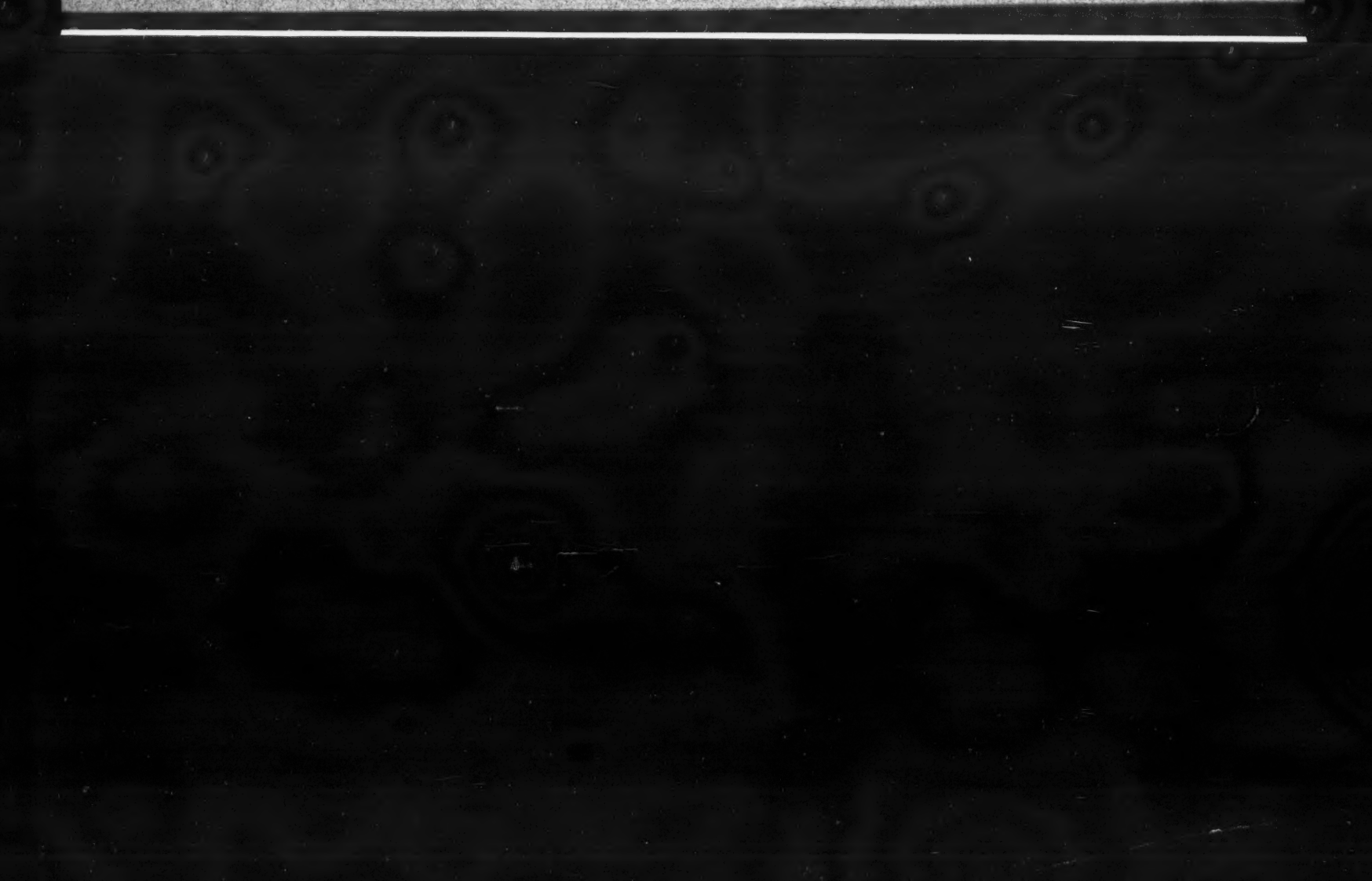

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